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IN...MATCHING-...AND.....
ODDITY-...TO-...SAMPLE.....
UNIVERSITY..UNIVERSITY.....OF.....ALBERTA.
DEGREE FOR WHICH THESIS WAS PRESENTED.....P.H.D.....
YEAR THIS DEGREE GRANTED.....1973.....

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UNIVERSITY OF ALBERTA
ACQUISITION DIFFERENCES IN MATCHING- AND ODDITY-TO-SAMPLE

by



VIRGINIA S. NILSSON

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE
OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF PSYCHOLOGY

EDMONTON, ALBERTA

FALL, 1973

THE UNIVERSITY OF ALBERTA

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YEAR THIS DEGREE GRANTED .. 1973 ..

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Acquisition Differences in Matching- and Oddity-to-Sample" submitted by Virginia S. Nilsson in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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ABSTRACT

This study was designed to examine the manner in which acquisition of a complex discrimination progressed, and how it might differ under different procedural variables.

Budgerigars were used as subjects. An apparatus which permitted three key discriminative key press responding is described.

A 2 X 3 factorial design with two birds per treatment was used to investigate both matching-to-sample and oddity-to-sample acquisition with three different correction procedures. The basic task involved a three key-two color complex discrimination. A response to a centered sample key turned on two comparison keys - one the same color as the sample and one different. Reinforcement was programmed either for a response to the comparison key which matched the sample, or to the key which differed. An incorrect response had one of three consequences, depending upon treatment group; a) no consequence: straight-correction b) termination of trial and repetition of that trial: modified correction c) termination of trial and advance to the next trial: noncorrection.

Acquisition was found to vary in terms of position preference, initial level of percent correct responding and total number of sessions to reach criterion. Variations in acquisition were a function of both correction procedure and matching-oddity procedure. Initial position preferences were quite strong for the noncorrection subjects, particularly those on the matching procedure, but were either much less marked or absent in the other two correction procedure conditions. The initial level of percent correct responding was higher for the oddity subjects than for the matching subjects. This difference was smallest for the subjects on the

noncorrection procedure. High asymptotic levels of responding were reached by all except the subjects on the matching X straight-correction condition. In that condition one subject leveled off at chance and the other stopped responding. The noncorrection procedure subjects reached asymptote more rapidly than the subjects on the other correction procedures.

The results are discussed with respect to previous work reporting matching-oddity acquisition differences, and are found to provide a rationale for the ambiguity which existed. The correction procedure used is considered to be the chief source of the differences in these studies. It is concluded that acquisition appears to proceed according to a successive, rather than a simultaneous discrimination, and is facilitated by the early use of position cues.

I wish to acknowledge the generous support of the THN Government Agency throughout all stages of this research.

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INTRODUCTION

Responding to a relation among stimuli rather than to a stimulus alone enables an organism to deal with its environment on some basis other than a one-to-one stimulus-response basis. One of the most elementary relationships which can be abstracted from an array of stimuli is that of same - different. An experimental procedure which investigates this relation is "matching-to-sample": A stimulus is presented as a sample to the subject and the subject is taught to select a stimulus which is the same as the sample from among two or more subsequently presented stimuli. Another such procedure, "oddity-to-sample", involves selection of a subsequent stimulus which is different from the sample. While it might appear that these two procedures are logically converse, it has been found that the acquisition of matching-to-sample differs from that of oddity-to-sample (Berryman, Cumming, Cohen & Johnson, 1965; Ginsburg, 1957). Does this difference between learning to choose that which is the same and that which is different represent some intrinsic aspect of the learning process or does it represent an artifact of experimental procedures?

Learning

If this difference in acquisition between matching-to-sample and oddity-to-sample is attributable to learning, then learning must evolve from systematic rather than random behavior. The conditional discrimination is a procedure which enables investigating whether behavior changes in systematic stages which may favor one problem or the other.

Random and systematic behavior interpretations. The classical distinction between continuity and noncontinuity theories of learning (Spence, 1951) recognizes two alternatives. On the noncontinuity side of the argument,

Krechevsky (1932) wrote that "Learning consists of changing from one systematic, generalized, purposive way of behaving to another and another until the problem is solved (pg. 532). These "...ways of behaving" were called hypotheses by Krechevsky who considered presolution hypotheses or "false solutions" as necessary, although not directly relevant, to the final solution of the problem. Likewise Lashley (1929) contended that "There are many indications that animals in the problem-box situation experiment with many solutions... Similarly in the discrimination box, response to position, to illumination or to cues from the experimenter's movements usually precede the reactions to the light and represent attempted solutions which are within the rats' customary range of activity (pg. 135)." Lashley considered these presolution hypotheses as irrelevant to the real solution.

On the other hand Spence (1936) considered behavior during the presolution period as quite relevant to the solution of a problem. Behavior, according to Spence, did not proceed in a chance or haphazard manner, but instead with what he called directive tendencies. These tendencies, brought into the situation by the subject partly as a result of experience, consisted of already learned associations and were initiated according to their respective strengths.

If learning is noncontinuous, then variations in the irrelevant presolution behavior on a matching or an oddity problem would have to be due to procedural variables. The irrelevancy of the behavior would preclude the influence of any consistent differences on solution. Therefore, even if differences existed they would not be part of the learning process. If learning was continuous (Spence, 1936), then the acquisition of different problems might proceed in different ways. Differences in the acquisition of a matching and an oddity problem could

be inherent in the learning process.

Testing alternatives via conditional discrimination.

Determining whether learning proceeds in a noncontinuous or a continuous fashion would help to indicate whether the matching and oddity acquisition differences could be due to training procedures or to the learning process. The conditional discrimination procedure facilitates investigation of this question because it provides for a number of response alternatives during the presolution period. The number of alternatives varies with the number of conditions built into the experimental procedure. If learning is noncontinuous, then training alone must underlie the differences since behavior during presolution, being irrelevant to the solution, cannot vary on different problems in any way which would affect solution. If learning is continuous, then there may be some patterns of behavior which originate during presolution which could differentially favor the acquisition of matching-to-sample or oddity-to-sample. These patterns of behavior should be evident in a record of responding as recurrent stimulus-response pairings. Such a finding would not preclude that the acquisition differences were training related, and this possibility would also have to be investigated.

The problem of conditional discrimination has received considerable attention in recent years under the guise of matching-to-sample, a restricted case of a conditional discrimination in which the conditional stimulus plays an active part in the discrimination (Blough, 1959; Cumming & Berryman, 1961, 1965; Ferster, 1960). In such a procedure one stimulus is presented as a sample. The subject is required to pick from among two or more other stimuli the one which is the same as, or matches, the sample. The procedure is frequently accompanied by another called nonmatching (Ginsburg, 1957;

Harlow, 1942) or oddity (Berryman, et al., 1965), in which the subject must pick from among the comparison stimuli the one which does not match the sample (or not pick the one which does match). (The term oddity has also been used as the name for a slightly different procedure in which the subject must pick from among three or more stimuli the one which differs from all the others, the one cue being the oddness (Moon & Harlow, 1955; Robinson, 1933). The conditional role of a sample stimulus, which is basic to matching-to-sample, is lacking in this other oddity procedure. These two oddity procedures must not be confused.)

A conditional discrimination paradigm lends itself well to an analysis of presolution behavior because it provides for many possible stimulus - response pairs to occur during solution of the problem. The number available depends upon the complexity of the discrimination problem. Cumming and Berryman (1965) discussed the study of stimulus - response pair patterns during presolution within the context of matching- and oddity-to-sample. They report that there do exist what they call incorrect 'hypotheses' (observed correlations between stimuli and responses) during presolution. They found that they could manipulate these 'hypotheses' to a certain extent by the experimental control of certain variables. For instance, "...when we have programmed reinforcement for simultaneous matching, the birds display an almost complete position preference. However, when the reinforcements are programmed for responses to the odd stimulus, no such substantial position habits emerge (pg. 325)."

The conditional discrimination paradigm provides a basis for the analysis of presolution behavior, but it will be necessary to examine the more recent work thoroughly before using it as a tool, so to speak, for looking at some other aspect of learning.

The more recent matching-to-sample work (Cumming &

Berryman, 1961; Ginsburg, 1957; Harlow, 1951; Skinner, 1950; Young & Harlow, 1943) has revealed discrepancies in the rate of acquisition of matching as opposed to oddity. Skinner reported that matching "is apparently no easier than" oddity. Ginsburg reported data which indicated that matching was not only no easier to acquire than oddity, but was in fact harder (Table 1). It began at a lower level of percent correct responding and took more time (more trials) to reach criterion. Berryman, et al. (1965) interpreted Skinner's statement as meaning that matching and oddity were acquired with equal ease and pointed to the "contradictory findings" of Skinner and Ginsburg. Berryman, et al. presented data contradictory to both Skinner's and Ginsburg's which showed that although oddity performance began at a higher percentage of correct responding as in Ginsburg's data, it improved at a slower rate than matching and did not reach as high a level of correct responding as matching performance after 20 sessions (Table 2).

Cumming & Berryman (1965) suggested a post hoc explanation of the acquisition difference of matching and oddity based on inference from their oddity transfer experiments. They were using three stimulus colors instead of two. One comparison stimulus was always the same as the sample and the second comparison stimulus could be either of two other colors. Following acquisition of oddity-to-sample a fourth stimulus color was substituted for one of the original three. If the original stimulus colors had been red, green and blue, then yellow was substituted for blue. As a result of this substitution three distinct stimulus patterns emerged. Some patterns were the same as the original acquisition patterns - red and green on the sample key and on both comparison keys. On other patterns the sample was now yellow, and the comparison stimuli were yellow on one side, and either red or green on the other side. On

Table 1

*Ginsburg's Data

Initial level percent correct		Number of trials to reach 80% correct	
Subjects		Subjects	
Matching	Oddity	Matching	Oddity
55	90	410	0
50	70	720	80
45	60	750	100
35	55	760	140
25	55	1080	150
20	50	1660	160
	50		200
$\bar{X} = 38$	$\bar{X} = 61$	$\bar{X} = 897$	$\bar{X} = 119$

* initial level (1955)
trials to 80% (1957)

Table 2

*Cumming and Berryman's Data

Initial level percent correct		Number of trials to reach 80% correct	
Matching	Subjects Oddity	Matching	Subjects Oddity
	75	490	300
only	73	440	610
averaged	67	730	660
data	67		930
given	57		1010
	52		1390
$\bar{X} = 50$	$\bar{X} = 65$	$\bar{X} = 553$	$\bar{X} = 817$

*1965

the third type of pattern the sample was red or green and one of the comparison stimuli was now yellow. Cumming and Berryman found that the level of correct responding remained unchanged for the first sort of pattern. Oddity performance was disrupted for both of the other two types of patterns, particularly the last, when the new color was present only as one of the comparison stimuli.

From these data Cumming and Berryman (1965) suggested that the sample stimulus functioned as a discriminative stimulus to 'respond' (S^D) rather than a discriminative stimulus to 'not respond' (S^A). The sample was telling the subject which comparison stimulus was correct, not which one was incorrect. If the sample was instructing which stimulus was incorrect the performance on the third type of pattern would not be as severely disrupted as on the second type of pattern since the instruction would not involve the new color.

A matching transfer experiment results in the same stimulus pattern changes, but because of the different relationship of sample to correct response the orderly gradations of disruption of performance would not be expected. When the new color was the sample, performance might be disrupted whether the sample was acting as an S^D or an S^A . On the third type of pattern, when the new color was the odd comparison, the instructions of the sample as either an S^D or an S^A would not include the new color, hence performance would not be disrupted.

An S^D function in the oddity context is more complex than in the matching context. In the matching, a red sample as an S^D instructs to "peck a red comparison stimulus". In oddity a red sample as an S^D instructs to "peck a blue or green comparison, whichever is available", a much more complex instruction. Similarly with a green sample it instructs to "peck green" or "peck red or blue", etc.

Ginsburg (1957) used only two color stimuli, in

which case a matching red sample instructed to "peck red" and an oddity red sample to "peck green": neither was more complex than the other in terms of the Cumming and Berryman analysis. Because of this Ginsburg's data should show matching and oddity acquisition rates to be more nearly equal than were those of Berryman, et al. Unfortunately the differences in the criterion of solution used by Ginsburg and Berryman, et al. make it difficult to compare the two studies or even to compare Ginsburg's matching and oddity rates beyond the 80 percent correct level of responding, as Berryman, et al. did.

If Skinner's statement that matching was no easier than oddity is taken to mean that their rates of acquisition were the same, this would support Cumming and Berryman's $S^D - S^A$ suggestion since Skinner used two color stimuli.

There are these three discrepant reports in the literature. For Skinner matching- and oddity-to-sample are learned in the same way. Ginsburg's subjects learned matching-to-sample with more difficulty than they learned oddity-to-sample. Berryman, et al. found that while responding on oddity-to-sample was initially superior to that on matching-to-sample, the difference was reversed later in acquisition. What is it about these studies which is causing these conflicting reports?

Experimental Procedure

Preliminary training, correction procedures and the criteria for solution are aspects of experimental procedures which are known to have differential effects on learning. Could these effects account for the difference between matching and oddity learning?

Training procedures differentially affect acquisition.

Before a subject can be expected to perform in any sort of learning experiment it is necessary to train him to make the appropriate response on the manipulandum provided. How this preliminary training is achieved may

have a subsequent effect on behavior and differentially favor matching or oddity acquisition (Berryman, et al., 1965; Devine & Iven, 1969; Nissen, Blum & Blum, 1948; Young & Harlow, 1943). The method used by Berryman, et al. involved response contingent primary reinforcement on all of the stimuli (keys and color) to be used in the matching and oddity procedures. After a certain number of reinforcements had been delivered the matching or oddity procedure was begun with primary reinforcement contingent only on responses to the comparison stimuli. Responses to the sample, although secondarily reinforced by the onset of the comparison stimuli, were extinguished with respect to immediate primary reinforcement. Such a procedure of extinction of responding to the sample may initially have facilitated oddity and acted detrimentally on matching performance. If the subject was not reinforced for a response to the sample the effect of this might have been that the next time that color was seen the subject would not respond to it, especially if there was another stimulus color available. That is, he would respond according to oddity-to-sample.

Ginsburg, on the other hand, never reinforced responding on the sample with primary reinforcement. Therefore, his data would not show an enhancement of oddity performance due to such reinforcement. Let us compare the Ginsburg and the Berryman, et al. studies with respect to the relative superiority of matching and oddity.

Initial levels of percent correct responding were higher for oddity than for matching in both the Ginsburg (1957) and the Berryman, et al. studies (Tables 1 and 2). Since initial oddity superiority was evident in both studies, it must not have been related to preliminary training which differed in the two studies. A comparison of time to reach criterion showed that in Ginsburg's study the oddity subjects reached the 80 percent correct criterion sooner (in fewer trials) than Berryman, et al.'s

oddy subjects did. Berryman, et al.'s method of preliminary training must not have been facilitating rate of acquisition. When Berryman, et al.'s subjects were run beyond 80 percent the oddity subjects took longer to reach asymptote than the matching subjects. On the basis of this third comparison it could be said that oddity performance was inferior to matching, but the reverse relationship in Ginsburg's data is not evident due to criterion differences.

Correction procedures may also affect acquisition. The consequences of an incorrect response in the learning of a discrimination present a problem. Some studies employ a straight-correction procedure, in which there are no programmed consequences and the organism is free to "correct his mistake" (Brookshire, 1970; Ginsburg, 1957; Hull & Spence, 1938; Riopelle, Hill & Rector, 1967). At the opposite extreme, a noncorrection procedure is one in which a wrong response is effective in terminating the trial and changing the stimulus pattern which will appear on the next trial (Bitterman, 1966; Brookshire, 1970; Cumming, Berryman & Cohen, 1965). One variation of this procedure is to terminate the trial without changing the stimulus pattern, so that the next trial is the same (Blough, 1959; Ferster, 1960; Stettner, Schultz & Levy, 1967). Such a method shall be referred to as a modified-correction procedure.

Some types of correction procedures may differentially facilitate matching or oddity. For instance, in modified-correction and straight-correction, especially the latter, it is possible to have a rapid sequence of 'incorrect response - correct response - reinforcement'. The incorrect response in such a sequence could be secondarily reinforced by the correct response or by attention to the correct stimulus (Fowler, Spelt & Wischner, 1967; Robbins, 1969), or even primarily reinforced through chaining (Bolles, 1967, 1970; Ferster, 1953). Spence (1936)

considered that there could be a spread of the strengthening of excitatory tendencies to responses more remote in time from the reinforcement, and perhaps even a dispersal of any inhibitory tendencies resulting from nonreinforcement of the incorrect response. Ginsburg (1957) discussed the possibility that if an incorrect - correct response sequence was reinforced that it would facilitate oddity behavior. In both the matching and oddity procedures responding to the two comparison stimuli in succession necessarily would mean responding to an odd stimulus since they would always be different from one another.

In a modified-correction procedure and in a noncorrection procedure it is conceivable that both correct and incorrect responses could be reinforced by the termination of the trial. A stimulus change such as trial termination has been found to have reinforcing properties (Hinde, 1966). However, this effect would be symmetrical for matching- and oddity-to-sample. Incorrect responding would not be reinforced at all by stimulus change in straight-correction since it would have no consequences, thus there would be no stimulus change (Ferster, 1953). The effect of a stimulus change type reinforcement of errors would be to slow the progress of both matching and oddity discriminations under conditions of noncorrection and modified-correction. In assessing the relative effect of correction procedure in the Ginsburg and the Berryman, et al. studies, the data in Tables 1 and 2 show that Ginsburg's subjects (straight-correction) began responding at a lower level of percent correct than Berryman, et al.'s subjects. (noncorrection). The theory of reinforcement of errors by stimulus change would predict the opposite effect for straight-correction versus noncorrection. In terms of the number of trials to reach the 80 percent correct level of responding, Ginsburg's oddity group was faster than Berryman, et al.'s oddity group. However, Ginsburg's

matching group was slower than Berryman, et al.'s.

Influence of criterion of solution. The data from different experiments can appear discrepant as a result of differences in the criterion used (Berryman, et al., 1965; Weitz, 1961). Berryman, et al. ran daily sessions of 140 trials until responding reached asymptote. They found that the asymptotic level for matching exceeded that for oddity and reached nearly one hundred percent. Ginsburg used a criterion of sixteen correct responses out of twenty, or 80 percent. Half of his subjects had sessions of twenty trials and the other half had forty trial sessions. The subjects with the forty trial sessions were required to attain 80 percent correct in both the first and second twenty trials. Ginsburg's data (Table 1) showed a mean number of trials to criterion for matching of almost eight times that for oddity. Thus while Berryman, et al. can say that oddity was harder than matching and Ginsburg can say that matching was harder than oddity, their conclusions are not based on comparable data. A proper comparison would have to be made at the 80 percent level in both studies. Berryman, et al.'s data in Table 2 showed that the number of trials to reach an 80 percent correct level was greater for the oddity subjects, a result opposite to Ginsburg's. Since the contradiction between Ginsburg and Berryman, et al. centers on the respective rates of acquisition of matching and oddity, and since Ginsburg did not run to asymptote, the two sets of data cannot be adequately compared on this point.

Aim of the Present Study

The present study was designed to examine differences in behavior during the acquisition of matching- and oddity-to-sample. At the same time the effects of training factors known to influence acquisition were observed. Preliminary training was designed to minimize the

possibility of differential influences on subsequent discrimination acquisition and performance. Subjects were run on either matching or oddity, and on one of three correction procedures, either straight-correction, modified-correction or noncorrection. Behavioral records were analyzed in such a way as to reveal whether learning proceeded in a continuing series of systematic stages or by means of either random or systematic discontinuous behavior. Any response patterns evident during the period of presolution would be further studied to determine if they intrinsically favored matching or oddity learning.

METHOD

Subjects

Most recent studies on matching-to-sample have used the pigeon as a subject (Cumming & Berryman, 1965; Ferster, 1960; Ginsburg, 1957). It was decided for this research to use budgerigars (Melopsittacus undulatus), although they have been used very little in learning experiments (Brookshire, 1970; Cogan, 1971; Dawson & Foss, 1965; Ginsburg, 1960; Ginsburg & Nilsson, 1971). Space and maintenance considerations were of major importance in this decision, and one would presume that the same basic principles of learning would hold for both birds (Brookshire, 1970; Harlow, 1958; Hinde, 1966). Whether or not the same stimulus - response patterns would be used by pigeons and budgerigars is not at issue, and in fact it is not even known if they would be the same among members of the same species.

Male and female budgerigars were used. They were obtained locally in groups of eight. Each group was purchased when the birds were about two months old, at which time they weighed between twenty-five and thirty-five grams. They were individually housed in standard bird cages and given free access to mixed grain and to water. When the birds arrived in the laboratory they were banded for identification and randomly assigned to the cells of a 2 X 3 factorial design involving matching and oddity and three different correction procedures. This left two spare birds from each group to use as replacements in cases of death or failure to condition.

Apparatus

The experimental cage was a 20 X 20 X 27.5 cm. mesh cage with one side and the bottom partially cut out to accommodate the stimulus-response-reinforcement units. Both the cage and the stimulus-response-reinforcement units

were housed inside a lighted and sound attenuated Lehigh Valley Medium Universal Cubicle number 132-04. The stimulus-response-reinforcement units were designed by T. H. Nilsson and the author. One of these units is shown in Figure 1. The response keys were horizontal and required a downward peck of 5.5 grams on the center key and 3.5 grams on the side keys to close a microswitch. A downward peck is the natural response for the budgerigar (Brockway, 1964). The keys themselves were made by frosting microscope slides with number 600 grit. The stimulus lights were 28 volt Dialco units number 507-3917 (red, green and white). The lights illuminated the entire response key. The key units, when inserted into the experimental cage, were 0.6 cm. off the bottom of the cage, projected 1.9 cm. into the cage and were spaced 0.3 cm. apart. The actual lighted pecking surface was 1.25 cm. by 2.5 cm.

Reinforcement consisted of a few grains of millet. It was delivered by means of a solenoid which drew a slotted arm back into the grain reservoir and then released it, causing the grain which had dropped into the slot to fall down the trough, as pictured in Figure 1. Grain quantity was determined by random arrangement of grain in the reservoir and varied nonsystematically from 1 to 4. (There are about 30 grains in the trough in Figure 1). The experimental cage was dimly illuminated at all times.

Programming was by means of a Computer Mechanisms Corporation 24VDC tape reader model number 18 in conjunction with BRS component cards. There were four different stimulus patterns possible: GRR, RRG, GGR and RGG. (R indicates red and G indicates green on the left, center and right keys respectively). Manual switches set the procedure for oddity or matching, and for which of the three correction procedures to be in effect. Responses were recorded on eight 24V Sodeco resettable counters type TCe24E (numbers 629 and 449707). There



Figure 1. Stimulus-response-reinforcement unit.

was one counter for left responses and one for right responses on each of the four stimulus patterns. In addition an Esterline Angus operation recorder (Int. trans. type, serial number 163451) sequentially recorded the stimulus pattern (sample and comparison colors), all responses, and reinforcement. The block diagram for the programming and recording circuitry is shown in Figure 2.

Procedure

The birds were weighed daily at approximately the same time each day until their weights had stabilized, about one week. At this time each bird was placed in the experimental apparatus for ten minutes on two consecutive days. These sessions constituted habituation to the experimental situation and during this time a single stimulus-response-reinforcement unit was present in the center position and illuminated with a white light. At random intervals during habituation reinforcement was delivered, the key was simultaneously turned out, and after a delay turned on again. After the second habituation session food was removed from the home cages and the birds were thereafter fed only enough to keep them at between 87 and 92 percent of their stable body weights, and running efficiently.

Beginning with the third session a key peck response was shaped on the single central key. Shaping continued until the bird readily pecked the key fifty times for regular reinforcement two days in succession. Daily shaping sessions were ten to fifteen minutes in length. Initially the cubicle door was open so the experimenter could see when to deliver a reinforcement. Simultaneously with reinforcement the key light was turned out and the intertrial interval begun. This interval was gradually lengthened from about 3 seconds to a maximum of about 30 seconds (Terrace, 1963). Once the subject had begun responding on the key and reinforcement was being delivered automatically, the cubicle

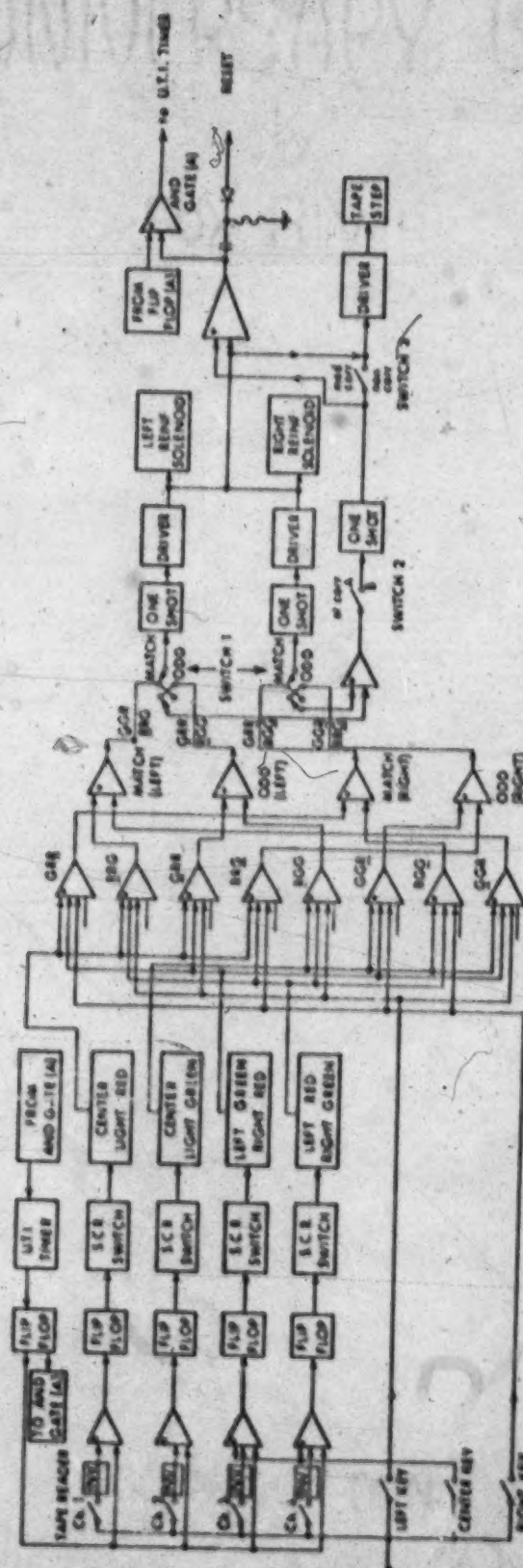


Figure 2. Block diagram of control circuitry.

door was closed. It was possible to observe the subject in the cubicle through a small fish eye peep hole in the door. Shaping took an average of three sessions, ranging from one to six sessions for different birds.

On the day after shaping was completed three stimulus-response-reinforcement units with colored lights were introduced into the cage. A balanced nonsystematic schedule of red and green on the left and the right keys was programmed, with the center key always dark and pecks on it ineffective. Intertrial interval was set at 5 seconds. Pecks to the lighted key were reinforced during two sessions of fifty reinforcements each. In the next session matching or oddity training and the appropriate correction procedure were begun.

In all cases a simultaneous discrimination procedure was in effect. A trial began with the center key being turned on. A response on this key resulted in the side or comparison keys being turned on. One of these keys was the same as the sample and the other was different. The sample key remained on. The colors used were red and green. Those subjects assigned to the matching procedure were then required to respond on the comparison key which was the same color as the sample. Subjects on the oddity procedure were required to respond on the comparison key which was different from the sample. For all subjects, a correct response resulted simultaneously in all three keys being turned off and reinforcement being presented. A correct response also initiated a 5 second intertrial interval and stepped the paper tape program to the next trial. Responses on unlighted keys were ineffective, as were responses on the sample key once the comparison keys were lighted.

The consequences of an incorrect response on the comparison keys varied with the three correction procedures. In the straight-correction procedure an incorrect response had no consequence, and the subject was free to respond

again and again until a correct response was made. In the modified-correction procedure an incorrect response was effective in terminating the trial (turning the keys off) and initiating the intertrial interval, but not in stepping the program tape or producing reinforcement. The trial was repeated until a correct response was made. In the noncorrection procedure an incorrect response terminated the trial, initiated the intertrial interval, and stepped the program tape to a new next trial.

A balanced, nonsystematic schedule of the experimental stimulus patterns, shown in Table 3, was programmed by means of paper tape. There were four different combinations of stimulus colors and keys called stimulus patterns: sample key red and comparison keys red on the left and green on the right (RRG), sample key red and comparison keys green on the left and red on the right (GRR), sample key green and comparison keys red on the left and green on the right (RGG), and sample key green and comparison keys green on the left and red on the right (GGR). The program schedule for each session was initiated at random locations on this tape. For purposes of later computer analysis there were no stimulus pattern repetitions programmed on successive trials. All sessions consisted of fifty reinforcements. The birds were run to a criterion of asymptote which was defined as a total of three sessions above 90 percent correct within a run of six successive sessions above 85 percent. This asymptotic level was redefined for the matching X straight-correction condition as less than 2 percent variation over five sessions when it became apparent that the subjects in this condition were not going to reach the high level asymptote. The asymptotes for the birds in this condition were 50 percent for subject number 9 and no responding for subject number 16. These sessions of no responding are not plotted on the figures.

RESULTS

The data reported here are from two groups of six birds. Two of these birds were replacements for birds which did not condition beyond the final shaping stage in the matching X modified-correction condition. When the matching-oddy procedure was instituted positional responding precluded reinforcement or program advancement for these birds and they eventually stopped responding altogether.

Figure 3 shows the percentage of correct responses for each subject as a function of sessions until criterion was met. The data are shown in pairs representing the two subjects in each treatment condition. There was close similarity in the performance of the two members of each pair. All subjects began responding at or below chance level (50 percent) on the first session. Except for the subjects in the matching X straight-correction condition they achieved a general increase toward 90 to 100 percent correct responding during subsequent sessions. There are some notable treatment condition differences.

- 1) Neither subject in the matching X straight-correction condition responded above a chance level. They were the only subjects which did not reach the learning criterion.
- 2) The number of sessions to reach criterion was less for the noncorrection subjects than the modified-correction subjects. A two-way analysis of variance of the modified- and noncorrection subjects (omitting those on the straight-correction procedure) showed this difference to be not significant (Table 4: $F_{(1,3)} = 9.17$; $p > .05$).
- 3) All subjects on the matching procedure started at a significantly lower level of percent correct responding than subjects on the oddity procedure (Table 5: $F_{(1,5)} = 52.64$; $p < .01$). This initial level of percent correct responding also varied with correction procedure. The difference between the matching and oddity subjects on

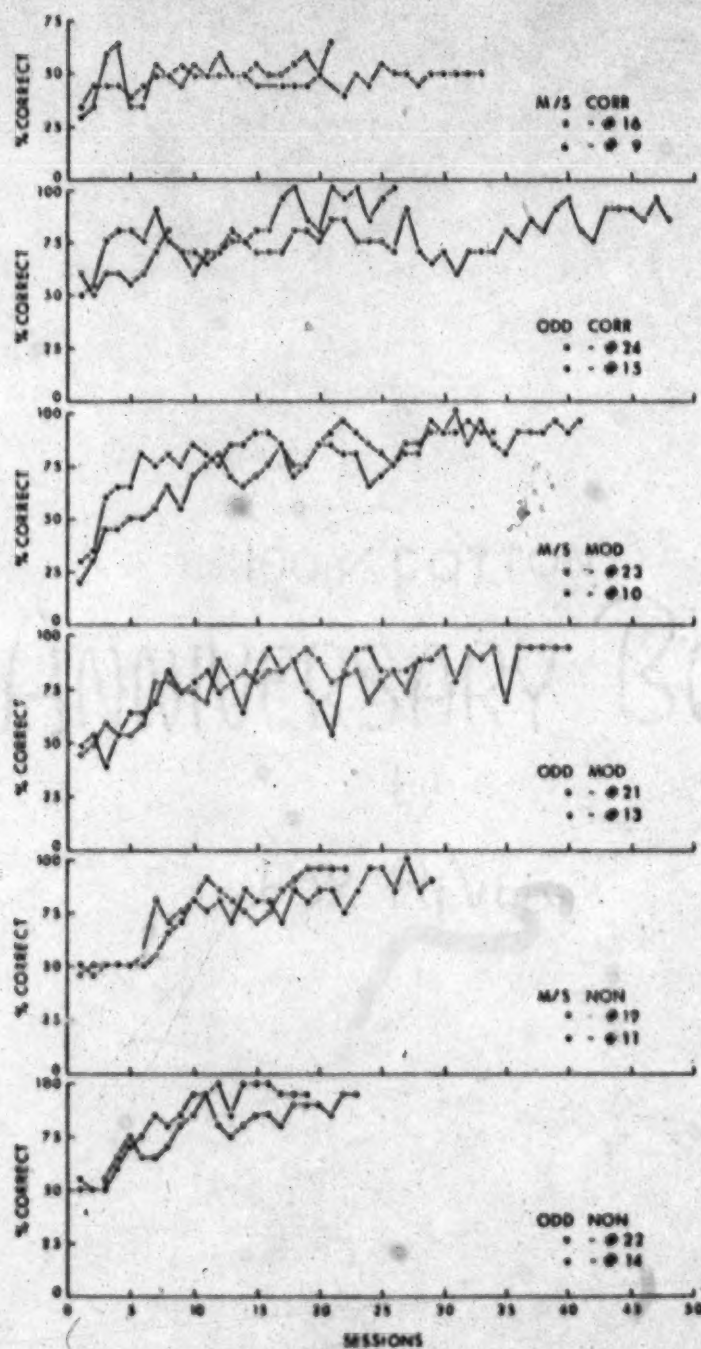


Figure 3. Percentage of correct responses on all trials per session. The curves are grouped according to treatment.

Table 4

Number of Sessions to Criterion

Group	Matching	Oddity
St-Corr	33 *	26
	26 *	48
Mod-Corr	34	28
	41	40
Non-Corr	29	19
	22	23

Analysis of Variance of Mod and Non Corr Groups

Source	df	MS	F	P
Replications	1	32.0	1.00	
M/S - Odd(A)	1	32.0	1.00	
Corr Proc(B)	1	312.5	9.70	> .05
A x B	1	0.5	0.02	
Error	3	32.3		

$$F(p=.05) = 10.13$$

- * - These values refer to the number of sessions to asymptote, but the level reached was not the high criterion level reached by the other groups. Because of this the entire St-Corr group was omitted from the analysis of variance.

Table 5

Initial Level of Percent Correct Responding

Group	Matching	Oddity
St-Corr	36	52
	32	58
Mod-Corr	28	52
	18	43
Non-Corr	48	53
	43	48

Analysis of Variance

Source	df	MS	F	p
Replications	1	60.75	3.76	>.05
M/S - Odd (A)	1	850.08	52.64	<.01
Corr Proc (B)	2	173.58	10.75	<.05
A x B	2	108.08	6.69	<.05
Error	5	16.15		

 $F(p=.05)=6.61$ & $(p=.01)=16.26$: df 1 & 5

 $F(p=.05)=5.79$ & $(p=.01)=13.27$: df 2 & 5

the noncorrection procedure was much smaller than the difference between the matching and oddity subjects on the other two correction procedures (Table 5: $F(2,5) = 10.75$; $p < .05$).

Figure 4 shows the percentage of responses made on the left comparison key as a function of sessions for each subject. Again, the pair within each condition performed similarly. The session to session variability of these results differed with correction procedure. In order to quantify this variability, the standard deviation of the points about the mean of each curve was computed and is shown in Table 6. The noncorrection subjects were most variable from one session to the next, and the modified-correction subjects varied least. Inspection of the curves in Figure 4 shows that the overall high variability of the noncorrection subjects can be attributed to the dichotomous nature of these curves: Strong initial position preferences were abruptly terminated and followed by only moderate position preferences during subsequent sessions. Omitting these initial sessions (the first 20 percent) resulted in the variance values which are shown in parentheses in Table 6. These values are lower and fall roughly between those of the straight-correction and modified-correction subjects.

Figure 4 reveals that for all subjects except those in the matching X straight-correction condition, positional responding was maintained at about the 50 percent level starting sometime prior to reaching criterion. Differences in the extent of positional responding existed in the initial sessions. Position preferences were studied by determining the mean percentage of responding made to the preferred side during the initial 10 percent of the sessions (Table 7). The matching X straight-correction subjects began responding at about chance level and developed a complete position preference (after approximately twelve sessions for subject number 9 and

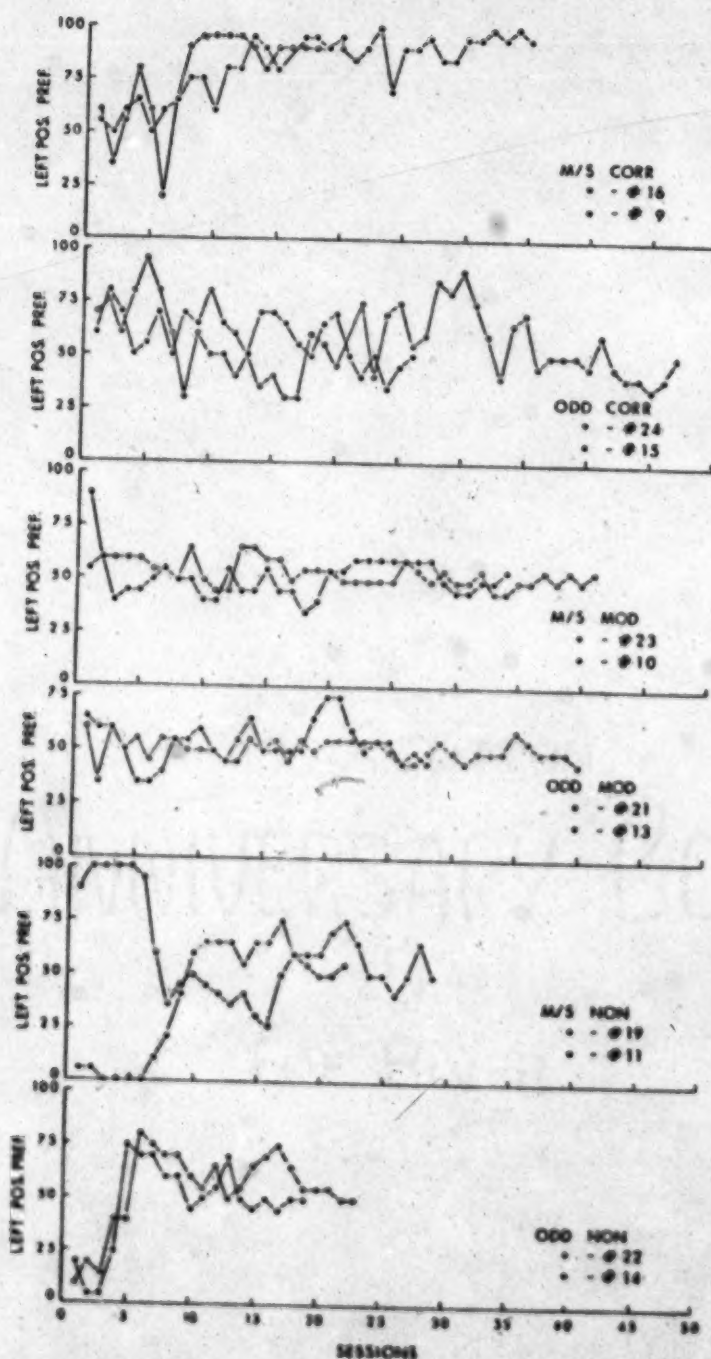


Figure 4. Percentage of trials in each session to which a left response was made. The curves are grouped according to treatment.

Table 6

Standard Deviation of Position Preference Curves

Group	Matching	Oddity
St-Corr	20.97	16.78
	15.75	11.40
Mod-Corr	7.48	4.80
	7.20	9.71
Non-Corr	25.21 (19.42)	18.81 (8.93)
	26.67 (16.33)	20.57 (10.22)

Note - Standard deviation was measured about the mean of each curve. Values in parentheses were computed omitting the first 20 percent of the sessions.

Table 7
Percent Positional Responding

Group	Matching	Oddity
St Corr	54	70
	51*	76
Mod Corr	53	62
	66	52
Non Corr	97*	86*
	95	86*

Note.- Positional responding is averaged over the first 10 percent of the sessions.

* - Mean percentage of responses on the right key - unstarred values are on left key.

Analysis of Variance

Source	df	MS	F	P
Replications	1	44.08	2.31	
M/S - Odd (A)	1	30.08	1.58	
Corr Proc (B)	2	1314.25	68.88	<.01
A x B	2	268.08	14.05	<.05
Error	5	19.08		

$F(p=.05)=6.61$ & $(p=.01)=16.26$: df 1 & 5

$F(p=.05)=5.79$ & $(p=.01)=13.27$: df 2 & 5

eight sessions for subject number 16). This preference was maintained throughout the remainder of the sessions. The oddity X straight-correction subjects began with percent-left-responding above chance level, at 70 and 76 percent left, and then responding on the left showed a slow, general decrease toward chance level. All the modified-correction subjects exhibited little position preference. Their positional responding was generally at chance level, both initially and across all sessions. All noncorrection subjects began with strong (over 85 percent) position preferences for one side or the other, then showed a slight preference for the opposite side, and finally showed no preference. A two-way analysis of variance of the initial preference data in Table 7 indicated that initial position preference was related to correction procedure ($F_{(2,5)} = 69; p < .01$). When strong initial preferences were shown, the subjects on the matching procedure showed stronger preferences than the oddity subjects. This interaction term is significant at the 5 percent level ($F_{(2,5)} = 14$).

A further analysis of position preference across sessions was undertaken by looking at the percentage of left responding on each of the four stimulus patterns (RRG, GRR, RGG and GGR). These data, which were not plotted, were nearly identical to the positional data in Figure 4. This indicated that preference did not vary according to color or position of any stimulus.

In Figure 5 the percentage of trials per session on which a response occurred to a particular color was plotted as a function of sessions for the two subjects in each treatment condition. It is seen that responding was consistently at or near chance throughout all sessions to criterion in all groups. At no time did any subjects show evidence of color preference. Figure 6 shows the percentage of correct responding as a function of sessions for subjects in each of the matching conditions. The data are

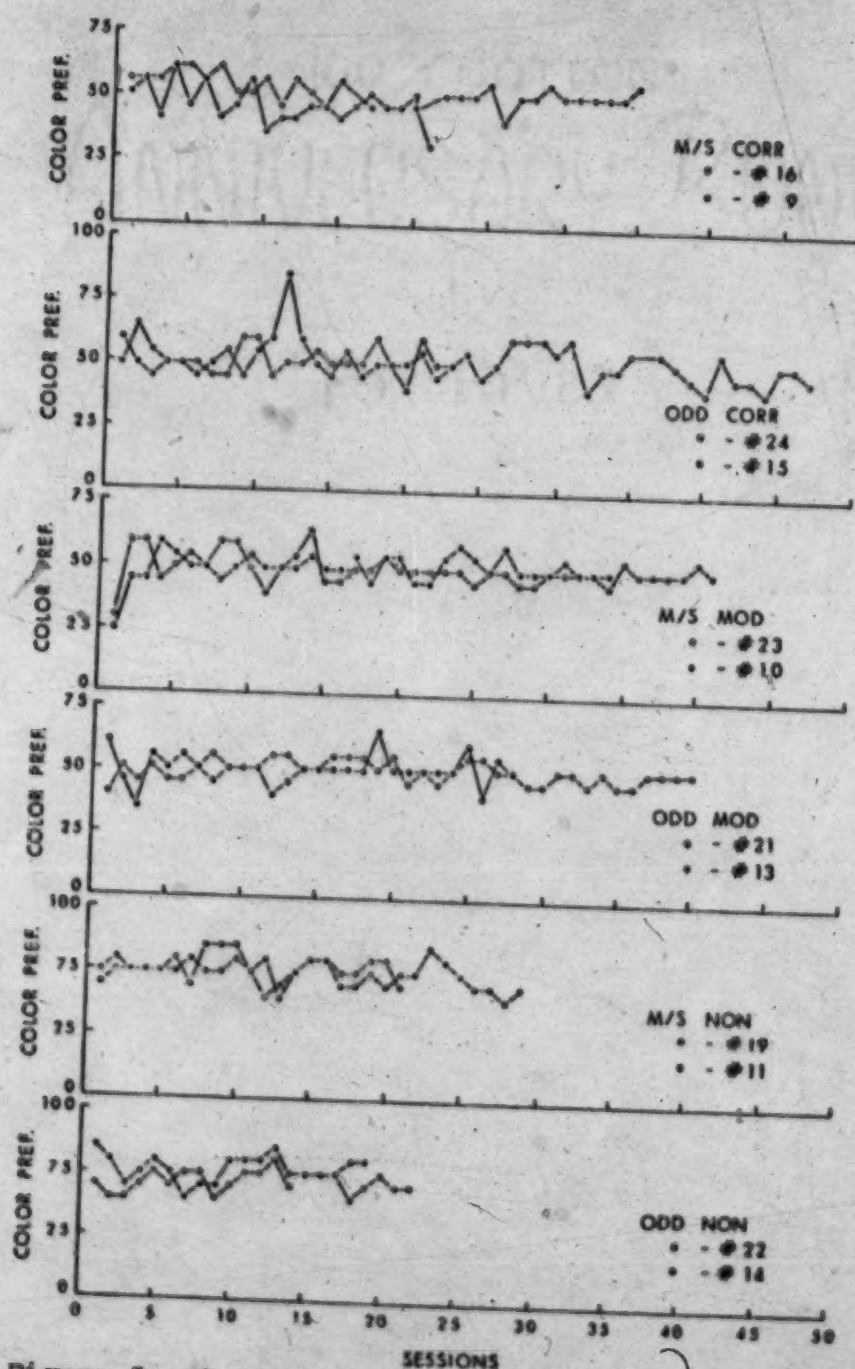


Figure 5. Percentage of trials in each session on which a response to red was made. The curves are grouped according to treatment.

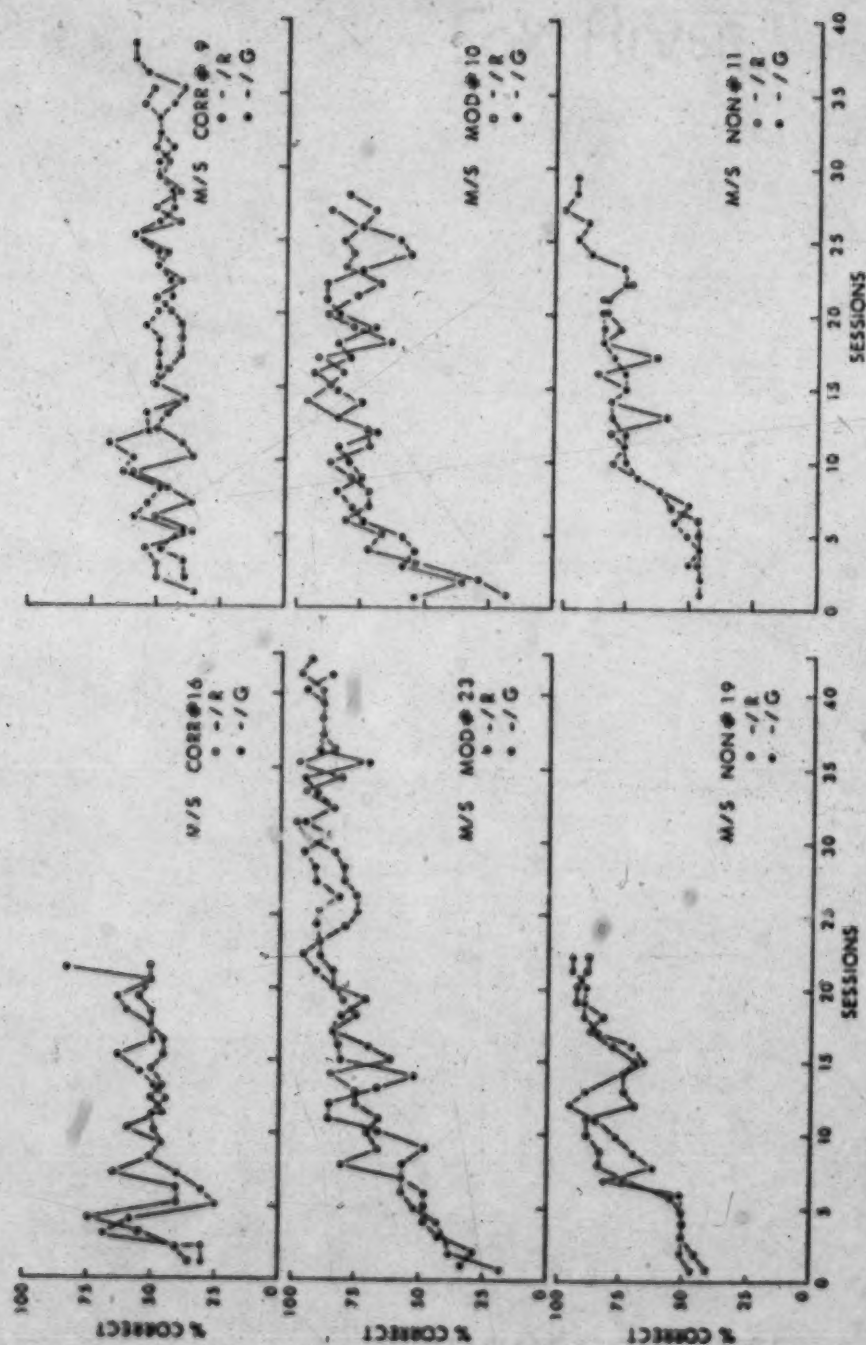


Figure 6. Percent correct responding per session plotted separately for red sample trials and green sample trials for each of the matching procedure subjects.

presented in pairs for each subject representing trials when the sample was red and trials when the sample was green. Figure 7 shows the same thing for subjects learning oddity. Here too, with the exception of subject number 15, color preference did not seem to influence responding. Responding on trials when the sample was red was nearly identical to responding when the sample was green.

Figures 8, 9, 10, 11, 12 and 13 show the percentage of correct responding for each subject on each of the four stimulus patterns (RRG, GRR, RGG and GGR). Responding for the matching X straight-correction subjects, Figure 8, reflected the development of a left position preference. On stimulus patterns for which a left response was correct (RRG and GGR), level of correct responding varied initially and then generally increased toward 100 percent. On stimulus patterns which required a right response (GRR and RGG), level of correct responding varied initially and then generally decreased toward 0 percent.

For the oddity X straight-correction subjects and all the modified-correction subjects, Figures 9, 10 and 11, responding reached a high and consistent level of percent correct in fewer sessions on those stimulus patterns for which a left response was correct (RRG and GGR for matching and RGG and GRR for oddity).

The noncorrection subjects, Figures 12 and 13, reached a high asymptote of percent correct responding and reached it first on those stimulus patterns which were 'favored' by their initial position preference. If a subject had a left position preference, then those stimulus patterns for which left was the correct response ('favored' patterns: RRG and GGR for matching and RGG and GRR for oddity) were responded to correctly. Those patterns on which a right response was correct (RGG and GRR for matching and RRG and GGR for oddity) were responded to incorrectly. As long as the position preference was

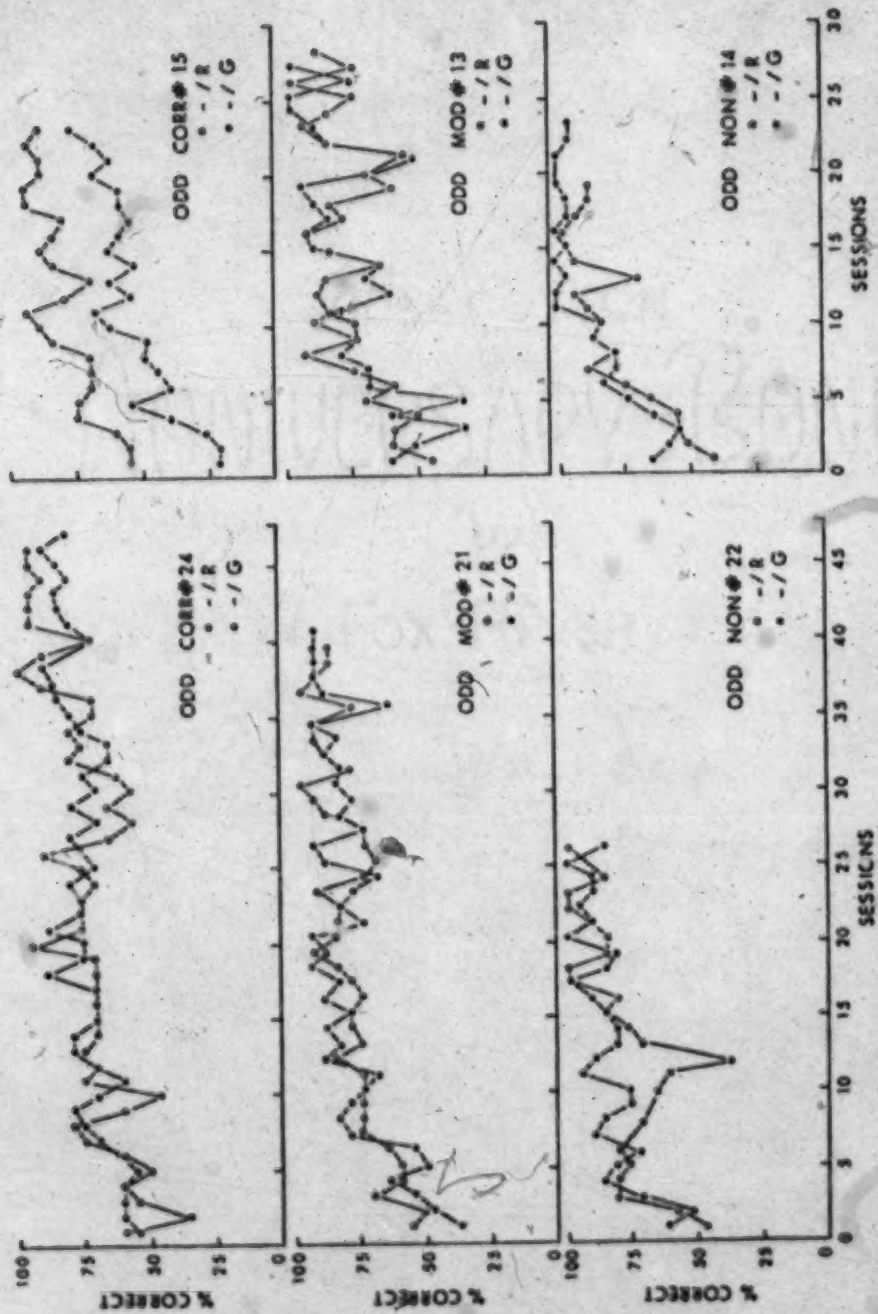


Figure 7. Percent correct responding per session plotted separately for red sample trials and green sample trials for each of the oddity procedure subjects.

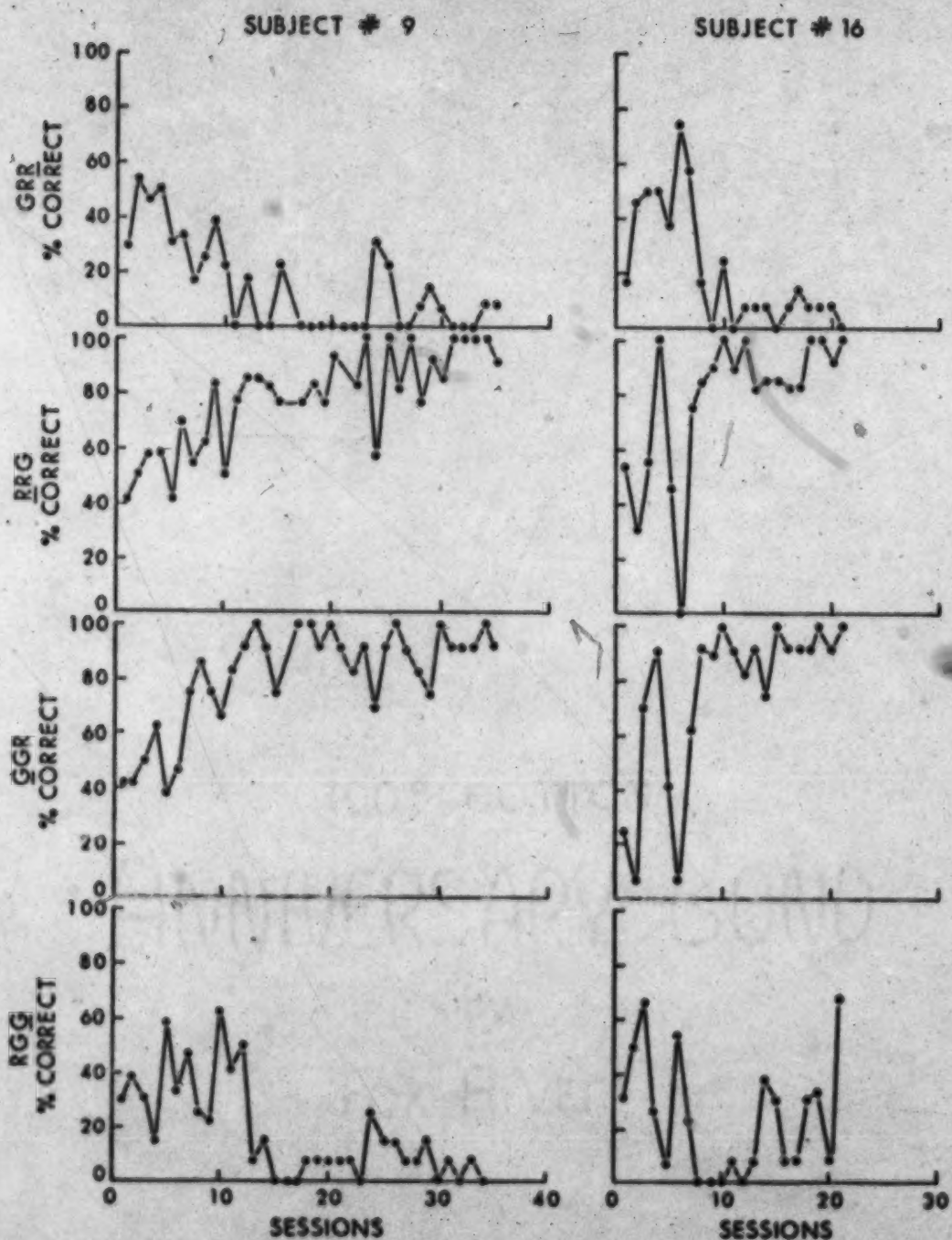


Figure 8. Percent correct responding over sessions on each of the stimulus patterns for the two matching X straight-correction procedure subjects.

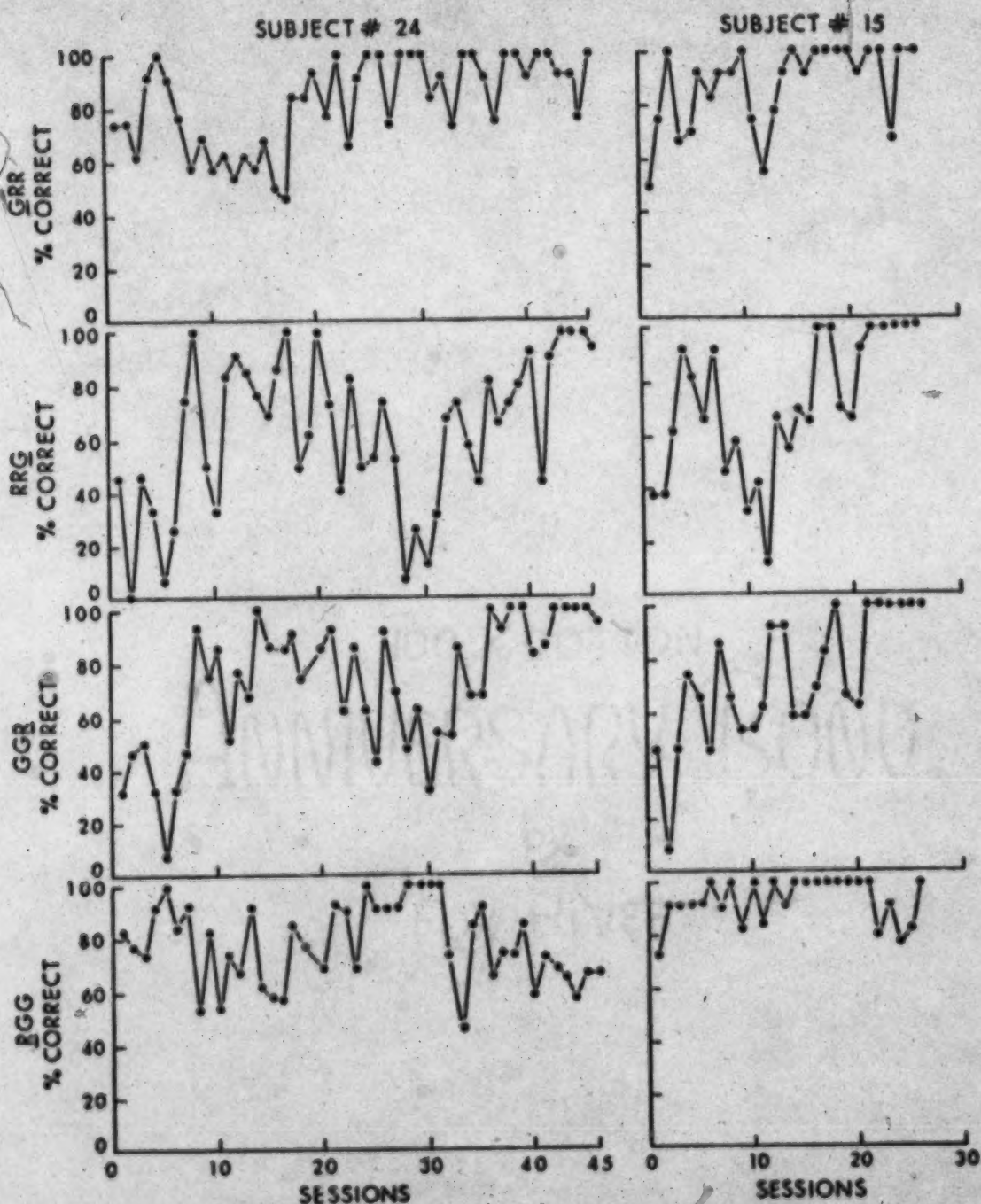


Figure 9. Percent correct responding over sessions on each of the stimulus patterns for the two oddity X straight-correction procedure subjects.

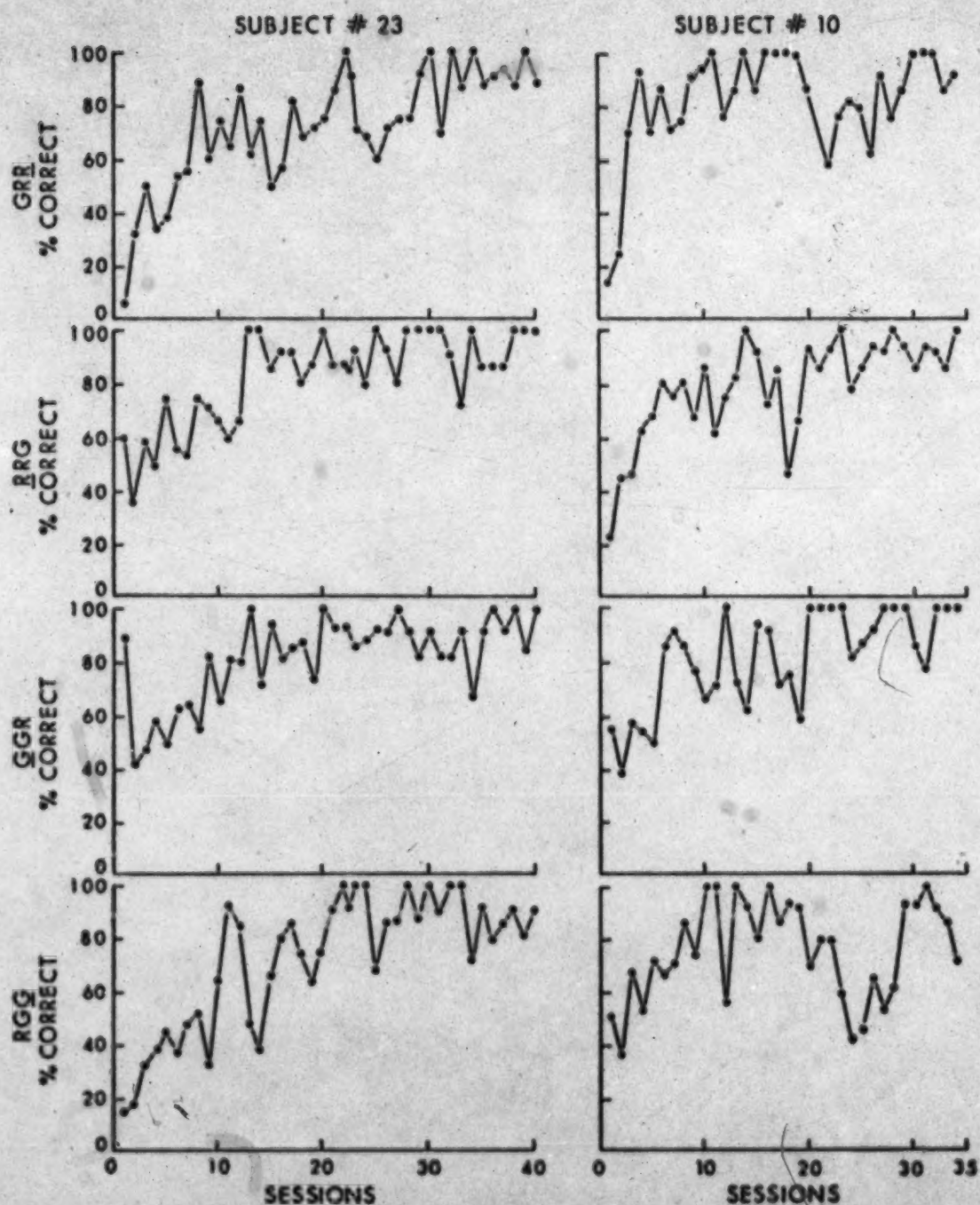


Figure 10. Percent correct responding over sessions on each of the stimulus patterns for the two matching X modified-correction procedure subjects.

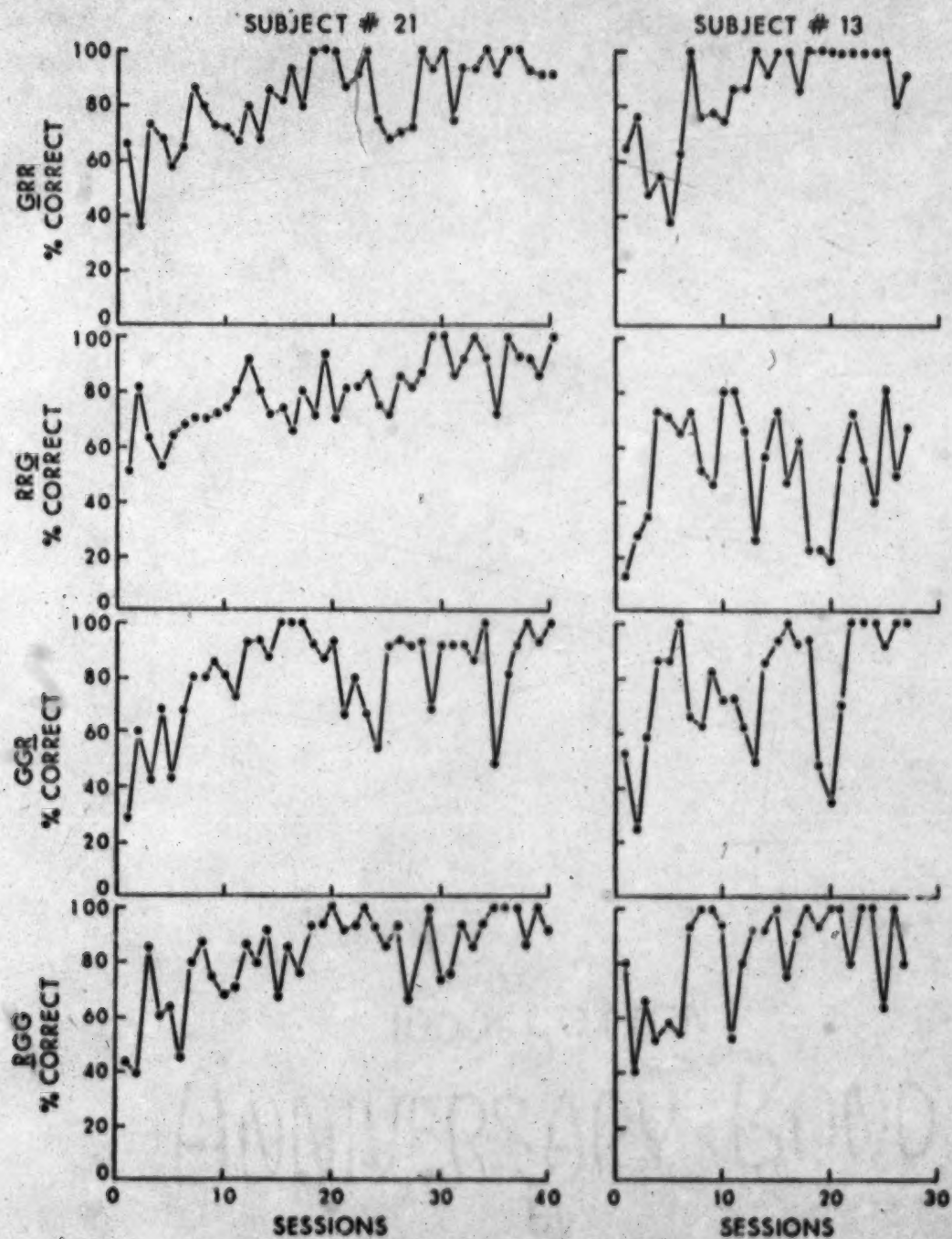


Figure 11. Percent correct responding over sessions on each of the stimulus patterns for the two oddity X modified correction procedure subjects.

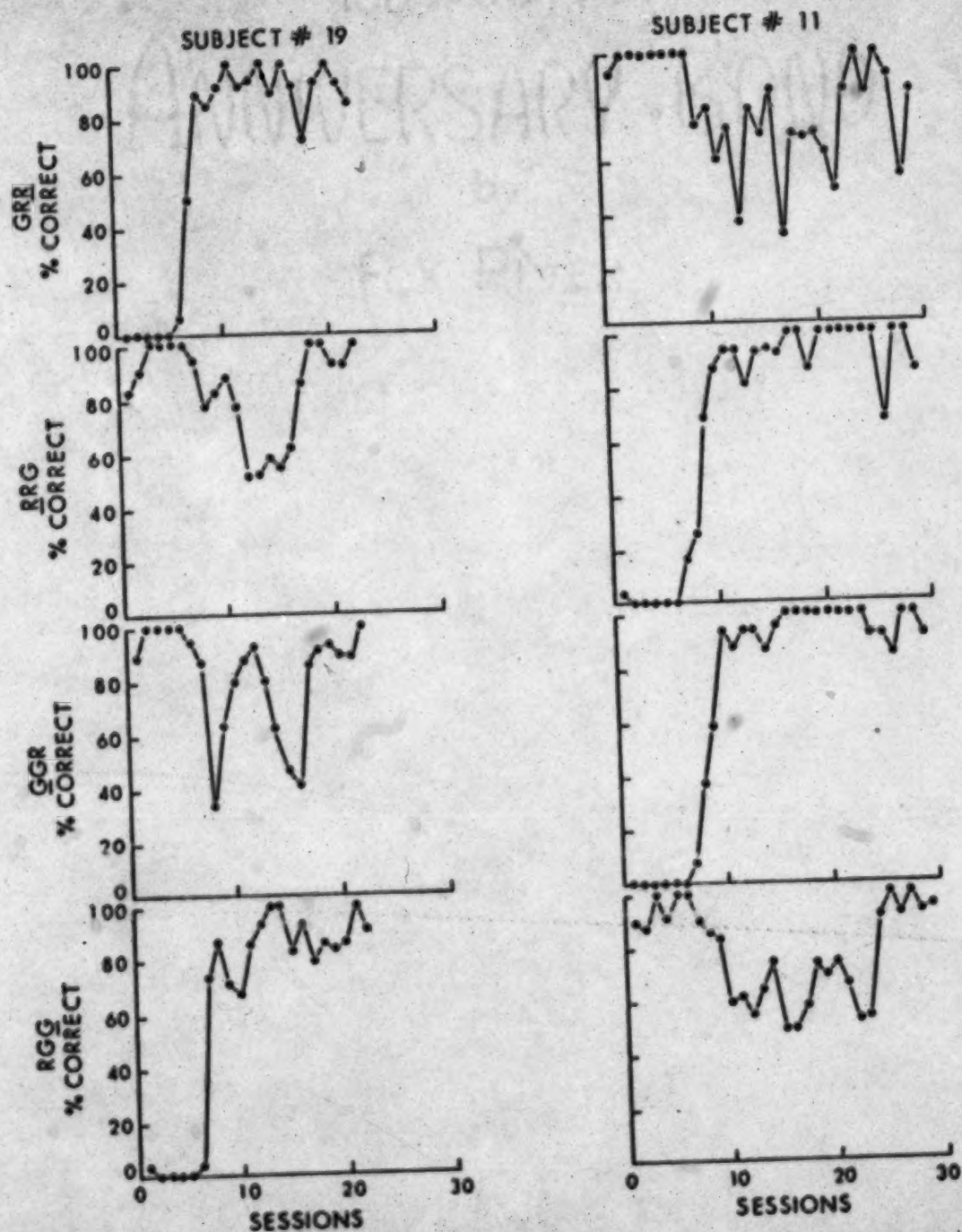


Figure 12. Percent correct responding over sessions on each of the stimulus patterns for the two matching X noncorrection procedure subjects.

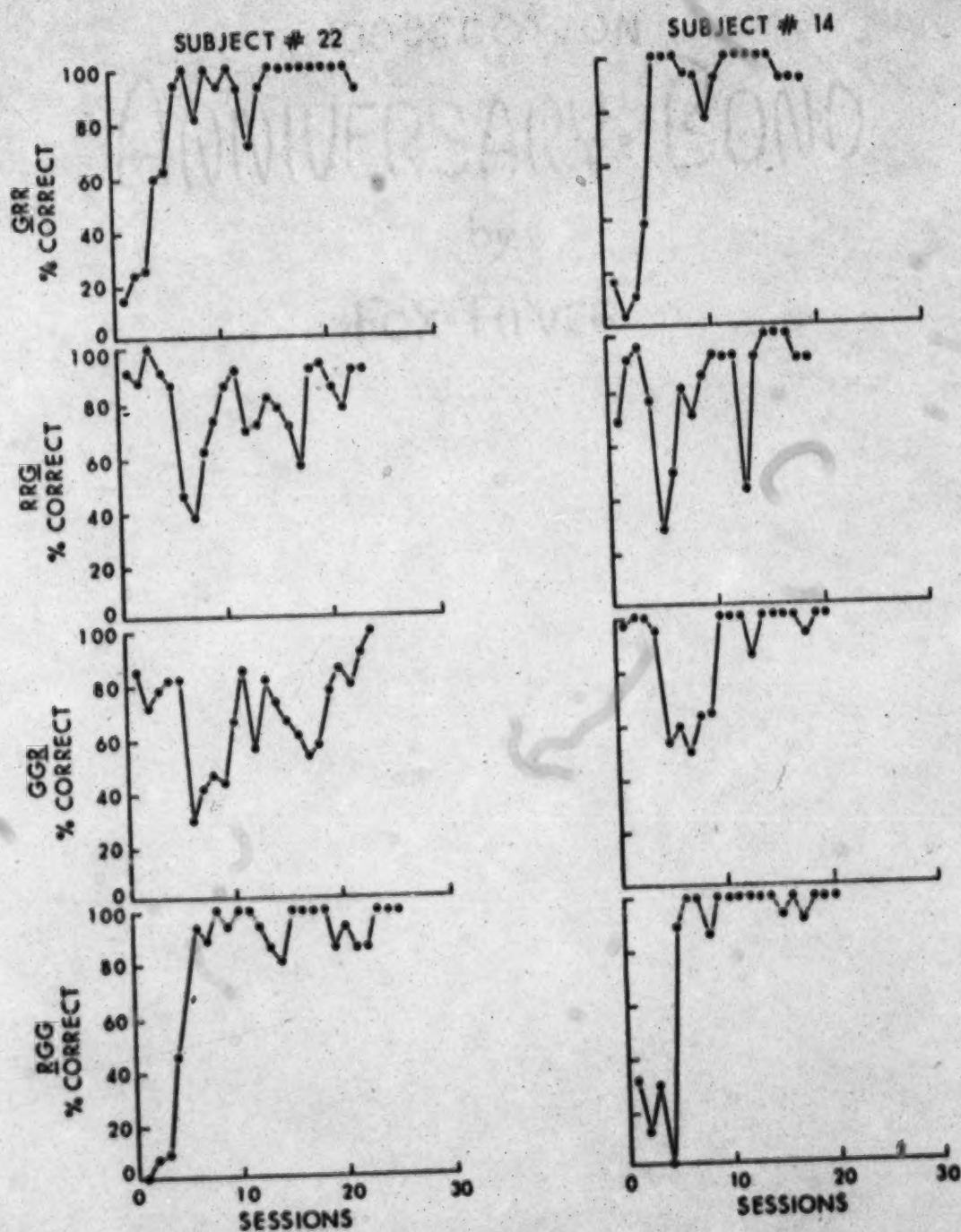


Figure 13. Percent correct responding over sessions on each of the stimulus patterns for the two oddity X noncorrection procedure subjects.

maintained the subjects responded at the 100 percent correct level on the two favored patterns and at the 0 percent correct level on the other two patterns. As the preference became less marked responding to the favored patterns did not remain at 100 percent correct but decreased to nearly chance level before returning to criterion level. Correct responding to the other two patterns increased to a higher level than the final level achieved on the patterns favored by the preference.

Responding to the different stimulus patterns is summarized in Table 8. The means and standard deviations of percent correct responding to each pattern were grouped according to whether a right or a left response was correct. Values for each subject were obtained from sessions which came after a double criterion was met. The criterion was defined as moderation of strong initial position preferences and responding above the 90 percent correct level on at least two of the four stimulus patterns. The oddity X straight-correction and all of the modified-correction subjects first solved those patterns on which a left response was correct (RRG and GGR for matching and RGG and GRR for oddity). That is, average percent correct responding was higher for the two patterns on which a left response was correct than for the patterns requiring a right response (straight-correction: $t = 2.97$, $p < .05$; modified-correction: $t = 4.14$, $p < .001$). The variability of percent correct responding was lower on these patterns which were solved first (straight-correction: $t = -3.75$, $p < .01$; modified-correction: $t = -2.72$, $p < .02$). The noncorrection subjects first solved those stimulus patterns for which a correct response was opposite to the strong initial preferences. The average percent correct was lower to the preferred and correct side ($t = 6.32$, $p < .001$) and the variability was higher ($t = 9.13$, $p < .001$).

In an effort to determine more precisely how

Table 8

Mean and standard deviation of percent correct responding to different stimulus patterns during final sessions averaged within each correction procedure

Corr Proc	Patterns on which left side is correct m/s - $\overline{RRG}$ & $\overline{GGR}$ odd - $\overline{RGG}$ & $\overline{GRR}$		Patterns on which right side is correct m/s - $R\overline{GG}$ & $G\overline{RR}$ odd - $RR\overline{G}$ & $GG\overline{R}$	
	$\overline{X}$	σ	$\overline{X}$	σ
St. (odd gp only)	86	13	75	22
Mod. (m/s & odd)	89	11	82	15
Non* (m/s & odd)	77	18	94	7.5

* Substitute 'preferred' and 'nonpreferred' sides for 'left' and 'right' sides respectively in column headings for this group. Preferred side is left for one subject and right for the other three.

acquisition proceeded or whether different procedures affected acquisition, several more detailed computer analyses were made of the behavioral records. A multiple regression analysis involving groups of several hundred consecutive trials over blocks of sessions was run to look for significant predictors of response on particular trials. There was no evidence that response on a particular trial was a simple function of responses on previous trials.

Another extensive computer analysis involved the grouping of trials within each session on the basis of which key the response was made on. Each group of trials was examined to see what features of the stimulus patterns of color and position they may have had in common. The only common stimulus feature evident within the groups of trials was the position of the comparison colors. This information reflected the position preference data already reported.

A third analysis involved a straightforward tally of responses in different response categories. These categories included runs and alternations of responding to position, incorrect responses during different segments of a session, shifting and not shifting of response position after a reinforced response, and shifting and not shifting of response position after a nonreinforced response. It was not possible to analyze all of the data in this way due to inadequate recording equipment. From the data available this third analysis provided some information as to what those subjects who did not have strong position preferences were doing during initial sessions. Some of this category data is presented in Tables 9 and 10. Table 9 shows how the matching X straight-correction subjects were responding during the initial (first 10 percent) sessions. Looking at the matching data, it is seen that subject number 9 initially responded to that position just reinforced, but other than this there was no predominant category for either subject

Table 9

Sample of Sessional Response Patterns
for Straight-Correction Procedure Subjects*

Session	Position		Pos Pref		Pos Resp after Reinf	
	Alt	Rep	Left	Right	Opp	Same
M/S S#16	1	57 42	54	46	38	62
	2	36 64	29	71	43	57
	3	40 60	39	61	53	47
	4	35 65	78	22	60	40
	5	63 37	52	48	33	67
	6	25 75	18	82	48	52
	7	49 51	60	40	43	57
	8	16 84	90	10	43	57
M/S S#9	1	59 39	52	48	22	78
	2	52 48	51	49	27	73
	3	51 49	58	42	39	61
	4	39 61	64	36	57	43
	5	50 50	48	52	57	43
	6	52 48	61	39	64	36
	7	35 65	66	34	63	37
	8	37 63	74	26	59	41
	9	41 59	74	26	53	47
	10**					
	11	29 71	80	20	52	48
	12	31 69	78	22	61	39
	13	21 79	90	10	47	53
	14	12 88	94	6	55	45
ODD S#15	1	45 55	60	40	65	35
	2	33 67	82	18	43	57
	3	51 49	72	28	45	55
ODD S#24	1	47 53	68	32	51	49
	2	29 71	75	25	47	53
	3	47 53	58	42	63	37
	4	35 65	80	20	51	49
	5	8 92	96	4	52	48

* Data represent percent of approximately 50 responses. Data for the matching subjects are for those initial sessions prior to the final position preference; for the oddity subjects, the initial 10 percent sessions.

** Data missing.

Table 10

Number of Response Alternations and Repetitions
During First 10 Percent of Sessions*

Subject	Session	Alternation	Repetition
M/S Mod #10	1	56	113
	2	40	53
	3	52	58
M/S Mod #23	1	28	121
	2	44	121
	3	44	67
	4	44	39
Odd Mod #13	1	47	44
	2**		
	3	50	70
Odd Mod #21	1	39	68
	2	43	55
	3	41	40
	4	32	35

* While number of reinforcements per session was 50, it was possible to have a great many more trials per session than reinforcements since an incorrect response terminated a trial without a reinforcement.

** Data missing.

until the development of position preferences. Subject number 9 showed a gradual but consistent development of the terminal left position preference while subject number 16 switched from left to right to no position preference before finally settling into the left preference. This was evident on the position preference curves too, in Figure 4. The oddity X straight-correction data show only the presence of moderate initial position preferences.

Table 10 shows position alternation and repetition during initial sessions for the subjects on the modified-correction procedure. It is seen that the matching X modified-correction subjects began with a preponderance of repetition responses in the first one or two sessions and then established somewhat of a balance between alternations and repetitions. On the other hand, the oddity X modified-correction subjects did not show such a dominance of response repetition initially. No other trends were evident in this analysis.

DISCUSSION

The purpose of this research has been to delineate the acquisition differences between matching-to-sample and oddity-to-sample. The problem has been one of determining whether these differences were inherent to the learning process, or were artifacts of the training procedures. Systematic response tendencies to different stimulus configurations during presolution were studied to see whether the presolution behavior during learning somehow intrinsically favored the acquisition of matching over oddity. It is known that variations in preliminary training, correction procedure and criterion of solution can result in diverse effects on performance. Preliminary training was designed to minimize the possibility of any differential effects on matching and oddity behavior. This was done by initially shaping the key peck response on a single key. Only after the response was learned were the three keys presented simultaneously. Responding on the center one of the three keys was never reinforced with food, and consequently never extinguished. Learning criteria were chosen to maximize the possibilities for any learning differences to become apparent. Various correction procedures were used to determine whether they had any selective effects on matching or oddity learning. Before discussing the matching-oddity differences evident in presolution behavior let us examine the contribution of correction procedure to performance difference.

Correction Procedure

With the exception of the matching X straight-correction group, all subjects followed a similar course in their learning behavior (Figure 3). The noncorrection subjects reached criterion level performance in the fewest sessions (Table 4). Their performance corresponds to

data reported by Cumming and Berryman (1965) who found that those subjects which adopted strong initial position preferences reached criterion sooner than subjects which responded according to some other system. For Cumming and Berryman this meant that their matching subjects reached criterion sooner than their oddity subjects, since under their noncorrection procedure the matching subjects exhibited stronger initial preferences than the oddity subjects. As seen in Figure 4, both the matching and oddity noncorrection subjects in the present study showed very much stronger initial position preference responding than the straight- and modified-correction subjects.

Analysis of position preference (Figure 4 and Tables 6 and 7) revealed other differences associated with correction procedure. The responding of the straight-correction subjects was characterized by high variability, moderate initial preference for those subjects learning oddity, and development of a complete preference in lieu of the high asymptote solution for those subjects learning matching. The modified-correction subjects showed very little variability or preference. The noncorrection subjects showed low variability but, as previously mentioned, strong initial preference. These differences in positional responding according to correction procedure can be explained, at least in part, by looking at the individual stimulus-response sequences which occurred.

Straight-correction. The straight-correction subjects did not make consistent use of position preference initially, although they could have obtained 50 percent reinforcement on the first response by such a preference. A more detailed sessional analysis of the early matching X straight-correction data (Table 9) indicated that instead of response patterns consistently based on position preference there was variation from session to session in the response patterns used. All of the other patterns

also resulted in approximately 50 percent reinforcement. This variation in response patterns could help to explain the high session to session variability of the positional response data in this condition. One of the more consistent of these other response patterns was responding to the side on which a response was reinforced on the previous trial (3rd column, Table 9). This pattern of responding meant there was a somewhat higher frequency of responding to the odd stimulus since the stimulus which was on the same side as the previous correct and reinforced stimulus was odd 65 percent of the time. In the case of matching, such a response would be incorrect. This tendency of the matching subjects to respond odd could explain why they did not reach the solution criterion, but instead developed a position preference.

Ginsburg (1957) suggested that on a straight-correction procedure the incorrect response might be getting reinforced by its close association in time to the correct response. Alternatively, the ease of making an incorrect response might make it negligible in terms of energy output, and hence persistent over time. Both of these possibilities could have led to the behavior which the subjects on the matching X straight-correction condition eventually exhibited. If responses on both keys were being reinforced, and the wrong response was being made almost automatically, then the development of a position preference would not be surprising. It has been shown that the probability of an animal resorting to a position preference during discrimination training is high even when the discriminative cues are quite distinct (Harlow, 1959; Irwin, 1958; Krechevsky, 1932). And in the case described here for the matching X straight-correction condition the discriminative cues were not even very distinct.

One reason why the oddity X straight-correction subjects did not resort to a final position preference might be that instead of switching from one response

pattern to another they developed moderate position preferences. Unlike some of the other response patterns available, position preference did not differentially favor matching or oddity responding. While it is true, as with the matching X straight-correction procedure subjects, that incorrect responses may have been getting reinforced, still oddity behavior eventually predominated and reached criterion. One subject showed a slight tendency to respond to the side opposite that which was reinforced (subject number 15, Table 9). However the moderate degree of position preference accounted for his tendency: on one trial the subject switched from his preferred side to the correct side for reinforcement, and on the succeeding trial switched back to his preferred side.

Modified-correction. A very strong color or position preference for a subject in a modified-correction condition would mean that one trial would be repeatedly presented, and the program and the subject would be 'stuck' at that point. At least program advancement would be very slow, and consequently reinforcements few. For example, if the subject had a strong left position preference the program would never advance beyond the first trial which required a right response. The subject would respond left, the trial would terminate and after the intertrial interval the same trial would be repeated. But if a left response was incorrect a right response next would be guaranteed correct. The subject would have to eventually respond right in order to get another type of trial. Position preference would result in close to 0 percent reinforcement while responding to almost any other cue would increase the probability of reinforcement.

Alternation of position responses would yield approximately 75 percent reinforcement. (Every trial on which an incorrect response was made would be followed by a correct response on the next trial since it would be the same stimulus pattern. Half of the total number of responses then would be contributing 25 percent reinforcement

while the other half of the responses would be correct, contributing 50 percent reinforcement.) A strong color preference would result in 50 percent reinforcement. Two modified-correction procedure subjects, both in the matching condition, had to be replaced for responding to the same position. They got 'stuck' responding on one side until they finally stopped responding altogether early in training. Table 10 gives a more detailed picture of how the other subjects were responding. The record of response alternations and repetitions shows that the responding of the successful matching X modified-correction subjects was characterized by repetitive positional responding, whereas the oddity X modified-correction subjects showed responses fairly evenly distributed between repetition and alternation of position. It appears that there was a tendency for these successful matching X modified-correction subjects to respond initially in accordance with a position preference.

Why did the oddity X modified-correction subjects not show this tendency as well? Since a position preference is not evident in the data in Figure 4, it would seem that what appeared to be a position preference in the data in Table 10 was actually the manifestation of another response tendency, a tendency to respond to a stimulus which was different, novel, or odd. This would not necessarily mean that the subjects were operating on an oddity-to-sample principle. The subject could have ignored the relationship between the sample key and the comparison keys and responded on the one key in three which was different. Even more simply, when the comparison keys came on that key which was a different color could have attracted the subjects' attention. The key which was the same color would go unnoticed. In a modified-correction procedure a tendency to respond to the odd or novel stimulus would result in reinforcement on an oddity condition and nonreinforcement on a matching condition. Thus, the

failure of two matching X modified-correction subjects to condition at all could be accounted for by saying that their tendency to respond to the odd stimulus resulted in trial repetition and response repetition to such an extent that these particular subjects stopped responding. A tendency to respond to the odd stimulus in the modified-correction procedure could also explain the higher initial level of percent correct responding for the subjects on the oddity condition (Table 5). The low session to session variability of the positional response data (Table 6) can be attributed to these modified-correction procedure subjects being limited in their stimulus-response sequences to the tendency to respond odd.

Noncorrection. In the noncorrection procedure, as in the straight-correction procedure, a subject could obtain 50 percent reinforcement by adopting a position preference. And in contrast to the modified-correction procedure, the termination of a trial due to an incorrect response served to advance the program to the next programmed trial. In this case the subjects on both the matching and the oddity procedures immediately adopted a complete position preference, unlike the subjects in the straight- and modified-correction procedures. Why these subjects did adopt such strong preferences so quickly and the straight-correction subjects did not must be related to the correction procedure, and to the fact that in the noncorrection procedure an incorrect response meant so much more in terms of time and effort. The implications of these strong initial preferences will be discussed in the next section.

Stimulus-Response Sequences during Presolution

When the position preference data, Figure 4 and Table 7, were interpreted in conjunction with the data of percent correct responding to each of the four stimulus

patterns, Figures 8 - 13 and Table 8, another response tendency became evident. On the noncorrection procedure (Figures 12 and 13) responding proceeded in either one of two ways according to the subjects' initial position preferences. Those two patterns for which a preferred position response was incorrect (GRR and RGG for subjects number 19, 22 and 14 and RRG and GGR for subject number 11) were solved sooner than the two patterns for which a preferred position response was correct (favored patterns: RRG and GGR for subjects number 19, 22 and 14, and GRR and RGG for subject number 11).

Responding on the two patterns which were solved first began at 0 percent correct, because of the position preference, and then increased abruptly to nearly 100 percent correct. The change in percent correct response level occurred in the same session for both of these stimulus patterns. The simultaneity of the changes would suggest that the subjects were responding to some common feature of the two stimulus patterns, the obvious one being the position of the stimulus which was correct.

Responding on the other two stimulus patterns, those which were favored by position preference, began at over 90 percent correct, decreased to chance level and then generally increased to near 90 to 100 percent correct.

The modified-correction procedure subjects and the oddity X straight-correction subjects first solved those two stimulus patterns for which a left response was correct. Unlike the noncorrection subjects, these subjects had only a very moderate initial position preference, for the left in all cases. In contrast to the noncorrection subjects which solved the two nonfavored stimulus patterns first, the modified- and straight-correction subjects solved the two favored patterns first.

It is interesting that responding on patterns favored by strong initial position preferences in noncorrection did not remain at the 90 to 100 percent correct level when the

position preference disappeared. It would appear that learning was proceeding in a noncontinuous fashion on these two patterns. Learning seemed continuous on the other two patterns on the noncorrection procedure and on all patterns when using the modified- and straight-correction procedures. If the subjects were learning to respond on the basis of a matching- or oddity-to-sample conditional discrimination principle one would not expect learning to proceed differentially on different stimulus patterns. The presence of these stimulus pattern differences suggested that the subjects might have been learning the correct position response to each particular pattern. Rather than the intended conditional discrimination the subjects approached it as a successive discrimination task.

Matching versus Oddity

Berryman, et al. (1965) and Ginsburg (1957) have made conflicting claims, each on the basis of his data, about the relative difficulty of learning a matching or an oddity problem. The claims in both cases were based upon two factors: speed of acquisition and initial level of percent correct responding. Thus far we have seen that correction procedure is quite a relevant variable where these two factors are concerned. Let us now look for evidence of matching-oddity differences which are independent of correction procedure.

Considering speed of acquisition first, the matching subjects on a straight-correction procedure never reached the high asymptotic response level, or solution criterion of their oddity counterparts. Hence it could be said that the oddity subjects reached solution criterion earlier than the matching subjects. The spread of effect of the reinforcer to the incorrect response, plus the effortlessness of making an incorrect response may explain why the

matching X straight-correction subjects did not reach the solution criterion but developed a position preference. Perhaps requiring a more complex response would preclude the development of this position behavior and permit the subject to more readily reach the solution criterion. For example, a ratio schedule of reinforcement would not only mean that the response itself required more work, but also that the eventual reinforcement would be more remote from the incorrect response. Within the other correction procedures, subjects on the oddity problem required only slightly fewer sessions to reach solution criterion than subjects on matching (Table 4).

Initial level of percent correct responding was the other difference between matching and oddity performance found in the literature. The present data show that subjects learning oddity began at a higher level than subjects learning matching (Table 5). Cumming and Berryman (1965) and Ginsburg (1957) both reported this difference also. Unlike the Cumming and Berryman data however, in the present study this matching-oddity difference was very small for the noncorrection subjects. Initial levels, and therefore rates, are nearly the same for the noncorrection procedure subjects. For the subjects in the modified- and straight-correction procedures, because oddity responding began at a higher level of percent correct than matching and took about the same amount of time to reach criterion (Table 4), the rate of acquisition of oddity was slower. The fact that the rates of acquisition were not equal suggests that perhaps the matching and oddity problems were not being learned in the same way.

The fact that responding to oddity began at a higher level of percent correct could mean that the subjects approached the task with a tendency to respond according to an oddity principle. Such an inherent tendency to

respond odd should have given sufficient advantage to the subjects on oddity to enable them to reach solution criterion sooner than the subjects on matching. However, this was not the case for any condition (Table 4). Considering the performance of the subjects in the matching X straight-correction condition, an initial tendency to respond odd may have been another reason why these subjects did not learn the matching task in the prescribed way while the oddity straight-correction subjects did. As described earlier, the incorrect response was being reinforced, and the effort in making an incorrect response was negligible. In addition the subject had a stronger tendency to respond to the odd stimulus than to the matching stimulus.

Reinforcement of oddity behavior in both the matching and the oddity conditions may result when a subject is trained on a straight-correction procedure. If the subject pecks the incorrect comparison key color and then switches his response to the other comparison key, the correct one, he will be reinforced for an oddity sequence of responding. In a matching condition the response sequence would be responding to red (sample), then green (incorrect comparison), then red (correct comparison). In an oddity condition the response sequence would be slightly different since the first two-responses made would be to the same color. That is, the subjects would respond red (sample), then red (incorrect comparison), then green (correct comparison). In both conditions the comparison key responses constitute an oddity sequence which is followed by reinforcement.

Comparing the data from the noncorrection procedure to that from the modified-correction, it would seem that those subjects which employed a strong position habit initially, namely the noncorrection subjects,

learned the task faster. The matching X and oddity X noncorrection subjects began responding at nearly the same level of percent correct and took the same amount of time to reach criterion (Table 4). Rates of acquisition for both matching and oddity subjects on a noncorrection procedure were equal. An initial position preference served as a response cue which maintained behavior during early acquisition. When responding was systematic in this way there was no matching - oddity difference.

In the case where no initial preference was evident, the initial level varied for matching and oddity subjects and rate was lower for matching. The question of why only one of the correction procedures (noncorrection) fostered initial position preference, or why the other two correction procedures fostered some other way of responding initially, is answered by comparing what happens in the stimulus-response sequencing if a position preference is employed. As noted earlier, for the modified- and straight-correction groups a position preference meant the program would not advance. Why did not these subjects adopt some other consistent and simple mode of responding initially? This depends upon what modes were available to the subject. Color or brightness would seem an obvious cue, but perhaps not to budgerigars since the data show that the birds did not respond differentially to it. Or they could have used a position alternation mode of responding (Bolles, 1967; Mowrer, 1960; Montgomery, 1952a). Instead, oddity seemed to be the mode of responding used. However, what appeared to be oddity may also be described as response to novelty (Hinde, 1966; Montgomery, 1951, 1952b) or perhaps even due to the physical aspects of the apparatus. The subjects had been conditioned to peck

a single central key, and then were conditioned to peck only the side keys. During side key conditioning only one key was on at a time and reinforcement was delivered equally (50 percent of the time) to each side and to each color. When the final matching or oddity procedure was instituted, it would seem reasonable that the subject would peck the first key that came to its attention. When the center key came on it pecked it. Then, when the comparison keys came on, that key which was of a different color would likely have been the one to have caught the subject's attention, and hence to have been pecked. Perhaps this response tendency could have been forestalled by changing the stimulus panel so that there was more separation between the stimulus keys. This would require a greater change in the subjects' position when changing from a response on the sample key to a response on the comparison key, and also when comparing the two comparison keys. The subjects might pay more attention to the stimuli, and to the task. Such a change might also make the matching comparison stand out more distinctly from the sample so that it could compete better with the odd comparison for the subjects' attention.

On the modified-correction procedure the rate of acquisition for the oddity subjects was lower than the rate for the matching subjects. Responding according to the correct cue at the outset of the learning task resulted in a lower rate of acquisition - learning was not accelerated. Perhaps by beginning closer to solution the subject skipped some aspect of the learning process. He was therefore handicapped in the completion of the learning process and had a slower rate of acquisition. This agrees with the evidence discussed earlier concerning the noncorrection procedure. The subjects on noncorrection were slower to solve the problem for the stimulus

patterns which were favored by initial position preferences. The fact that the initial mode of responding was correct did not accelerate the learning of these stimulus patterns, but apparently retarded it with respect to the other stimulus patterns. Responding to the correct cue at the outset of acquisition did not facilitate learning.

There seemed to be no matching-oddity differences which were independent of correction procedure. In the straight- and modified-correction procedures initial levels of percent correct responding varied, probably as a result of a tendency to respond to the odd or novel stimulus. Instead of this tendency in the noncorrection group the subjects responded positionally. In the straight-correction procedure the final asymptote varied for the matching and the oddity subjects due to the matching subjects resorting to a position preference as a means of solution. In the modified- and noncorrection procedures the final asymptote was the same for the matching and the oddity subjects. Perhaps the reason why there were no matching-oddity differences was because the subjects were learning a successive discrimination involving different stimulus patterns, instead of matching and oddity conditional discriminations.

Beyond the Stimulus and the Response

Discriminative behavior can be dichotomized into successive and simultaneous (Lovejoy, 1968). In a successive discrimination procedure only one of two or more stimulus values is presented on a given trial and different responses are appropriate for each stimulus value. It is Lovejoy's contention that in a successive discrimination the subject learns the appropriate response, "response selects", on each trial. Response 'A' becomes associated with stimulus 'A' and response 'B' with stimulus 'B'. On the other hand, in a simultaneous discrimination

two or more stimulus values are presented together on a trial and a single response is appropriate to only one of them. Lovejoy suggests that here the subject learns to choose the stimulus to which a response will be made, or "stimulus selects". If 'A' is the correct stimulus the subject will learn to respond to 'A' whenever it appears regardless of its position or the presence of other stimuli in combination with it. Lovejoy made an extensive survey of behavioral records from research on this topic, looking for evidence of stimulus selection or response selection in simultaneous and successive discrimination procedures. He found that the literature supported his distinctions of response selection on successive discriminations and stimulus selection on simultaneous discriminations. The present study was designed as a simultaneous discrimination, but it is possible to think of the four different stimulus patterns used here as four stimulus patterns in a successive discrimination. The data should tell if the subjects were stimulus selecting or response selecting.

Cumming, et al. (1965) investigated the possibility that subjects treated a simultaneous discrimination as successive in their study of the generalization of simultaneous matching to a novel stimulus. They used a three-color matching procedure as described above, on page 5, rather than the two-color procedure used in the present study. After the simultaneous matching task had been learned, a new color was substituted for one of the original colors. Matching was disrupted only on those trials in which the new color was the one to be matched. On trials in which the new color was the nonmatching comparison, matching behavior was not disrupted. This indicates that the subjects were not responding to each of the stimulus patterns separately as though it was a successive discrimination. If they were, then behavior would have been disrupted on all trials which used the new

color. Berryman,  al. (1965) made a similar substitution in their study of the generalization of oddity. In all cases the new color was on a key which required a response, either the sample or one of the comparisons. Whether the subjects were learning a simultaneous or a successive discrimination therefore could not be determined from that study.

The present study did not include a test by stimulus substitution of whether subjects were responding to successively presented stimulus patterns instead of stimulus selecting according to the relational principles of matching and oddity. However, the data showed consistent stimulus pattern order-of-solution effects, which suggested that the subjects were responding to a combination of stimulus pattern and positional cues. The data from the noncorrection condition showed that these subjects were responding to positional cues in terms of position preferences. The data from the modified- and straight-correction procedures showed stimulus pattern order-of-solution by position without this preference behavior interaction. Responding was controlled more by separate stimulus patterns than by a simultaneous matching or oddity principle. It may be that the subjects were working on a successive discrimination rather than the programmed simultaneous discrimination.

Perhaps something more complex than stimulus-response connections is involved here. It could be that no stereotyped or fixed stimulus-response patterns were involved, but rather more Tolmanian relationships such as a subject would develop by means of cognitive evaluation of his responses and the outcome of the past trials (Tolman, Richie & Kalish, 1946). Apart from consideration of whether the subject was learning a particular response in the presence of each different stimulus pattern, or learning to pick and respond to a particular stimulus, what was the subject doing? It seemed to be the case that those subjects

which initially adopted position preferences had an advantage over subjects which did not. Krechevsky (1932) contended that a subject responds according to one, then another and another mode of solution until success is achieved. What seemed to be the case in the present study was that the subject which responded consistently according to only one mode, position, achieved success sooner than subjects who were doing something else, perhaps trying various other hypotheses. Perhaps the systematic nature of the subject's positional responding enabled it to learn what behavior was and was not being reinforced and hence to shift more readily to responding to the correct stimuli.

This data showing that initial position preferences seemed to facilitate learning suggests a two stage learning process, somewhat like Sutherland's (1959). The first stage would involve determining the relevant stimulus dimension. In effect, by responding consistently to one position the subject could be considered to be simply observing the succession of trials, responses being of little importance. By always responding on the same key, the subject would not be interacting with the stimuli to any very great extent, but would be receiving reinforcement when the correct response was on the preferred side. The second stage, formation of stimulus-response associations, would evolve either after the position preference was discarded and responses were varying from trial to trial, or when the strength of responding to the correct cue was greater than the strength of the position preference (Spence, 1951).

CONCLUSIONS

Correction procedure was found to be a statistically significant factor in the learning of a conditional discrimination. Subjects on a noncorrection procedure solved both matching and oddity type conditional discriminations more rapidly than subjects on the other correction procedures. A relevant variable associated with this difference appeared to be position preference. Subjects on the noncorrection procedure adopted strong initial position preferences which were followed by a rapid rise to criterion level. Although the matching X noncorrection condition subjects showed a stronger initial preference than the oddity X noncorrection condition subjects, they did not reach criterion in significantly fewer trials. Subjects on the other two correction procedures, straight and modified, showed little initial preference behavior but did respond more in accordance with an oddity principle initially, regardless of whether they were on a matching or oddity procedure. In the modified-correction procedure the subsequent number of sessions to criterion was not less for those subjects working on the oddity problem. That is, rate of acquisition was lower for the oddity subjects. The matching X straight-correction subjects apparently solved the problem in a different way than the other groups. They adopted a position preference, correcting an incorrect response when necessary. Because the effort in making the incorrect responses was negligible they were essentially getting reinforced on every trial. The advantage given by beginning at a higher level of percent correct responding may be the reason why the oddity X straight-correction procedure subjects reached a high level asymptote while the matching X straight-correction procedure subjects did not. In all three correction procedures the matching subjects showed a greater tendency toward position preference than the

oddity subjects.

The strong interaction of matching-oddity differences with correction procedure would suggest that the differences found in previous work were due to procedural variables.

A comparison of responding to individual stimulus patterns revealed that those subjects which employed strong initial position preferences first solved the two stimulus patterns for which the correct position was opposite to their preference. The subjects with very moderate or no preference all solved first the stimulus patterns for which a left response was correct.

Looking for stimulus-response pairings in behavior during presolution did not reveal any consistent relationships which would indicate 'hypothesis' sampling in the manner described by Krechevsky (1932). From the evidence on order of solution of the four different stimulus patterns it was concluded that the subjects were probably not learning a simultaneous discrimination based on relationship. Instead, they were learning a successive discrimination, or learning the appropriate position response to each stimulus pattern.

There is no evidence of intrinsic differences in the learning of a discrimination depending on whether it is based upon a relationship of similarity or of difference. The difference between learning to choose that which is the same and that which is different represents an artifact of experimental procedures.

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APPENDIX

Budgerigars as Subjects

As an experimental subject the budgerigar has proven to be quite successful. Maintenance and space requirements are minimal, they are easy to condition, and work well for food reinforcement. Out of approximately thirty-six budgerigars with which I have worked only one has failed to condition. Three or four birds were run intermittently on pilot work over a period of two and one half years with no difficulty. Death rate was low and no birds have ever died during the course of an experiment. That is, death has only occurred before any conditioning took place, soon after coming into the laboratory, or after a study was concluded and the birds were simply being maintained on ad lib for long periods. Two birds had difficulty in conditioning because they walked on the response keys. However, a simple wire mesh shield over the keys through which the birds had to reach their heads in order to peck and receive the reinforcement quickly solved this problem. The major drawback in using budgerigars is that ready made equipment for their use is not available.

Previous work using the budgerigar (Ginsburg & Nilsson, 1971) also used a discrete trial procedure and had fairly short sessions. The range over which responses can be scheduled is not known at this time. In the Ginsburg and Nilsson study the final reinforcement schedule used was a VR12 and session length was twenty minutes. It is probable that either length or rate could be increased by decreasing amount of seed per reinforcement. In the present study the number of grains of seed per reinforcement varied from 1 to 4, while in the Ginsburg and Nilsson study a food cup was present for 2.5 seconds. On the basis of these two studies and personal observation it would seem likely that the birds would work

very effectively on an intermittent schedule with a minimal number of grains of seed for reinforcement, and for a period of time long enough to be useful in terms of data collection. Perhaps it would be possible to use the budgerigar with some other type of reinforcement than food; for example bird song (Ginsburg, 1960; Stevenson, 1967, 1969). It is the case that, because of its size, the budgerigar is quite sensitive to amount of deprivation of food. The range of percent body weight deprivation possible is narrow, and outside of this range the bird simply does not respond at all.